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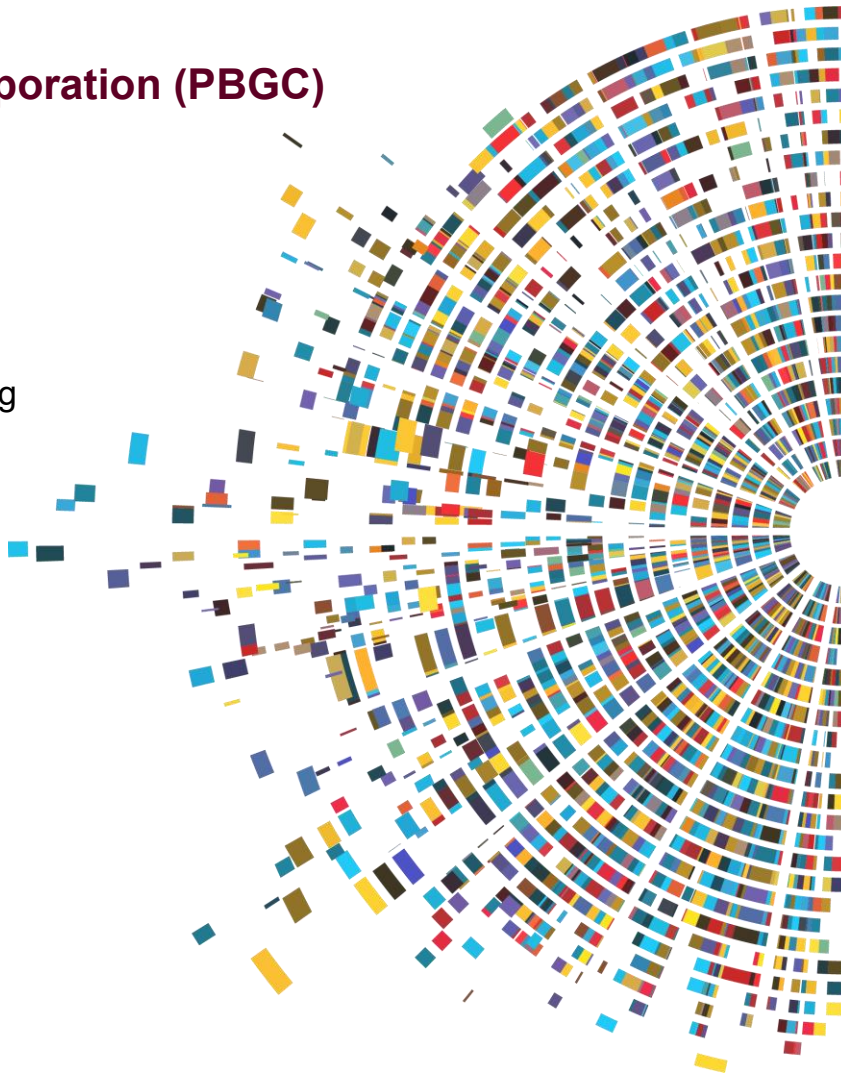
Pension Insurance Modeling System (PIMS) Independent Peer Review

Pension Benefit Guaranty Corporation (PBGC)



Actuarial Peer Review

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Executive Summary

The Moving Ahead for Progress in the 21st Century Act (MAP-21, Pub. L. No. 112-141) was enacted on July 6, 2012. Section 40233(a) of MAP-21 requires the Pension Benefit Guaranty Corporation (PBGC) to contract with a capable agency or organization that is independent of PBGC to conduct annual peer reviews of the Single-Employer (SE) Pension Insurance Modeling System (PIMS) and Multiemployer (ME) PIMS.

This report presents the reconciliation team's findings from review of the reasonableness and appropriateness of the Fiscal Year (FY) 2022 and FY 2023 projection results of the PBGC SE Legacy PIMS and Transformational-PIMS (T-PIMS) models. The Legacy PIMS model has been relied upon for over two decades. It has been recognized as a solid model to support understanding of the financial position of the PBGC SE program as well as to enhance understanding of the potential financial position of the program and its risks over the coming years. While the Legacy PIMS Model has been successful for many years, efforts have been made to modernize the model by enhancing its efficiency and bringing it up to date to utilize current modeling tools along with their sophistication and improved flexibility.

The primary objectives of this review were to:

- Identify material differences in the SE Legacy PIMS and T-PIMS model outputs for FY 2022 and FY 2023;
- Assess whether these differences are reasonable, in both direction and magnitude, based on differences in calculation methods or unreasonable due to model errors that require resolutions;
- Evaluate whether the results support the use and reliance of the SE T-PIMS model or indicate critical variances that must first be resolved prior to its official use;
- Summarize findings and provide recommendations for PBGC, including ME Legacy PIMS and T-PIMS model testing approaches based on the results of the review.

The results of our review related to these objectives have been documented in this report.

Our review focused on two major methodological changes and included a detailed review of the results of the actuarial model. The two key modeling changes between the Legacy PIMS Model and the T-PIMS model we reviewed are the Economic Scenario Generator and associated bankruptcy modeling and the way in which T-PIMS projects the SE Plan Universe. We discuss these modeling changes specifically and their strengths and weaknesses in the sections below. The reconciliation team also then considered the reasonableness of the actuarial modeling, comparing significant variables to trends, each other, and historical observations across models and projection years.

Key findings from our review are the following:

1. Economic Scenario Generator (ESG) and associated bankruptcy modeling: The T-PIMS model introduces a more dynamic and ESG responsive structure. The model performs well in replicating historical trends and demonstrates intuitive relationships between ESG results and bankruptcies. The model also projects a more conservative bankruptcy distribution. Specifically, compared to the historical patterns observed since 1981, the model generates a wider range of economic conditions across 500 simulations, leading to a more dispersed distribution of annual default rates, especially at the upper tail, for certain rating buckets (e.g.,

CCC_CC_C). We recommend considering additional refinements and extensions to the model to ensure projections are consistent with historical patterns as well as potential future shocks.

2. SE Plan Universe: The T-PIMS model now directly models all plans rather than extrapolating as was done in the Legacy PIMS Model. This shift enables a richer representation of plan characteristics such as industry or plan type, which is a significant advancement in the model. This change has introduced a difference of plan liabilities by approximately 5% compared to the Legacy results according to our FY 2022 analysis. We believe this should be tested further to affirm that the new approach is a better fit to actual experience. If it appears to deviate materially from actual experience, we recommend that PRAD consider improvements in future iterations of the model through calibration adjustments.
3. The Actuarial Model: Variable Rate Premiums produce an anomalous starting value. We suggest potentially initializing this variable with seed values based on current state data to improve early projection year accuracy. Additionally, once the new benefit payment methodology is implemented in T-PIMS, PRAD should prioritize studying plan benefit payment differences between model results. There are also a few variables, such as claims, that are heavily impacted by rare or uncommon events where the mean output is being pulled significantly away from the median. We recommend close consideration of the standard deviation of these variables to avoid overestimating the potential for significantly adverse events.
4. The T-PIMS model overall appears to be generally reasonable and reliable for use, replacing the Legacy PIMS Model to project the net position of the PBGC SE program over a multi-year time horizon. We understand that further parallel testing of the T-PIMS model is planned over the next year. Considering this, we recommend that the areas discussed above be considered and addressed where feasible prior to the first year of reliance on the T-PIMS model.

In conclusion, while the T-PIMS model has opportunity for additional refinement, it is a strong foundation for future use. It is generally suitable for its intended role in assessing the financial position of the PBGC Single-Employer program and assisting policy makers with understanding the risks inherent in the program.

Next Steps for Single-Employer T-PIMS

Looking ahead, an additional year of parallel testing is planned to be completed by PRAD, primarily to build additional confidence and to observe results incorporating the benefit payment streams that will then be available from Form 5500 data. This next phase of testing is expected to be critical, as benefit payments were identified during the current year's review as a primary driver of differences between the Legacy PIMS Model and the T-PIMS Model. Although the new source of benefit payments is expected to be an improvement, careful, targeted testing of this component will be essential to validate the T-PIMS performance with all inputs available.

As part of the broader transition to the T-PIMS model framework, several supporting steps should be undertaken to ensure long-term success and sustainability:

1. Model Documentation: Develop comprehensive documentation outlining the model's methodology, assumptions, data sources, governance framework, sensitivity profiles, and known limitations. This should include a model user guide for team members who will be running the model and a more brief model summary document for external stakeholders.
2. Governance and Monitoring Framework: Establish a formal model governance schedule, including regular performance reviews, calibration checks, and scenario testing protocols. Assign clear ownership for maintaining the model and associated documentation.
3. Define Key Performance Indicators (KPIs): Identify metrics to monitor model performance over time, such as variance from actual experience, input volatility impacts, or total runtime. Tracking these metrics over time will help flag emerging issues and prompt model maintenance.
4. Add additional flag fields: The T-PIMS model allows for the creation of fields that flag certain events happening during the projection. These fields could be used to identify outliers/tail behavior that should be studied further.
5. Consider policy-sensitive stress testing: Given the projections for both models show a positive net position for the Single-Employer program in almost all scenarios, PRAD should consider stress testing the results with different potential policies around premiums. PRAD can then consider how such policy changes may impact plan sponsor behavior and impacts on PBGC funding considerations.

These steps will help ensure that the T-PIMS model not only performs well today but remains well-governed, transparent, and adaptable to changing economic environments over time.

Multiemployer T-PIMS Insights

A review of the Multiemployer T-PIMS model results/development is critical given the complex policy environment and programmatic interventions, most notably the Special Financial Assistance (SFA) Program which fundamentally alters the landscape of insolvency risk and claim projections. As the PRAD team updates the ME Legacy model to a ME T-PIMS model, several insights emerged that should inform both the continued development of the SE T-PIMS model as well as the ME T-PIMS model:

1. As model variables are calibrated to historical experience, consider the spread of the tail risk and whether it matches historical data. Because the model is used to assess the adequacy of the program over long periods of time, the tail of the projections should have large enough spread to incorporate significantly adverse conditions. Historical data played a key role in increasing confidence in the SE T-PIMS model, especially in cases where output diverged from the Legacy model results. In several instances, the wider tail behavior observed in the T-PIMS model better reflected real-world experience and risk profile variability, highlighting the improved realism of the updated model framework.
2. Validation and Predictive testing: To improve future model calibration, it may be beneficial to hold out the final one or two years of historical data during development. This would allow for out-of-sample validation and more robust testing of predictive accuracy as the model is being

developed. Additionally, annual back-testing should be established as a formal exercise to continue monitoring the model's fit and predictive strength.

3. Sensitivity testing of novel model input sources is recommended. Key differences in model inputs should be considered prior to using them in the model. Assumptions used in selecting key inputs that the model is highly sensitive to should be discussed and selected carefully at the outset of model building. While we understand that PRAD intends to shift to using 5500 filing information for benefit payments as an input into the T-PIMS model, the appropriateness of using the 5500 filing benefit payment streams should be assessed when the initial year of data becomes available.
4. Involving an independent model validation team with both economists and actuaries significantly enhanced our understanding of the underlying pension plan modeling as well as the Economic Scenario Generator. This multidisciplinary approach facilitated a comprehensive analysis of the longer-term projections of liabilities and assets, as well as assessing the reasonability of the bankruptcy model. Given the effectiveness of this collaboration, it is strongly recommended to replicate this integrated methodology in future reviews to ensure robust and informed model testing.

Bankruptcy Models Review

Introduction

Within the broader PIMS, the bankruptcy model plays a particularly significant role in the SE-PIMS framework. This emphasis stems from the reality that the bankruptcy of a sponsoring company is a major trigger for the termination of single-employer pension plans that are underfunded, potentially leading to claims against the PBGC's insurance fund. The bankruptcy model is specifically designed to simulate and project the likelihood and potential consequences of sponsoring company bankruptcies on the insured pension plans. By analyzing various financial and economic factors, the model aims to forecast every company's risk of bankruptcy and how these potential failures could impact their pension plans and the PBGC's financial exposure. The output of the bankruptcy model is a critical input in the calculation of PBGC's net position, which reflects the agency's financial capacity to protect pension benefits.

This section compares and contrasts the Legacy PIMS bankruptcy model with its successor, the T-PIMS bankruptcy model. PBGC is currently in the process of implementing the new modernized, cloud-based, and parameter-driven T-PIMS for its SE Program, replacing the Legacy PIMS, an on-premises system that has been in operation for over two decades. A key objective of this transition to the T-PIMS bankruptcy model is to enhance PBGC's ability to accurately forecast bankruptcy, with a particular focus on improving the prediction of rare but high-impact tail events, such as the simultaneous insolvency of numerous pension plans. The T-PIMS bankruptcy model represents a significant modernization in model design compared to the Legacy PIMS, which has evolved through numerous iterations since its initial development. This section delves into the specific differences between these two models, analyzes the results of FY 2022 and FY 2023 simulation bankruptcy outputs between the T-PIMS and Legacy PIMS bankruptcy models, provides root cause analysis on potential reasons for the variances, and outlines future considerations and potential model improvements.

The overall findings from the reconciliation review of the Legacy PIMS and T-PIMS bankruptcy models include:

- Legacy PIMS and T-PIMS have several structural differences. The variation in Legacy PIMS bankruptcy rates is influenced by differences in annual firm-level characteristics. In T-PIMS, the variation in bankruptcy probability is tied to firms' credit rating bucket, and the bucket's default probability varies annually with macroeconomic indicators.
- T-PIMS provides bankruptcy projections with a larger distribution, consistently showing higher default counts compared to Legacy PIMS. This allows T-PIMS to better be able to understand potential shocks to the PBGC system given adverse economic conditions. However, T-PIMS may be generating a higher, more conservative estimate of defaults given the large range of projected defaults, particularly for certain credit rating buckets (i.e., CCC_CC, C), compared to historical patterns since 1981.
- The correlation of T-PIMS bankruptcy model's default rates with macroeconomic variables is economically intuitive.

Methodology

The reconciliation team's methodology for parallel testing involved a structured comparison of the Legacy PIMS and T-PIMS bankruptcy models across three key dimensions: structural design, model inputs and assumptions, and model outputs and results.

1) Comparison of Structural Differences
   - Outlined and compared the differences in bankruptcy model design and high-level architecture.
   - Examined how different inputs and parameters generate bankruptcy probabilities and simulated defaults.
   - Investigated if the T-PIMS incorporates a broader or more refined set of variables for sponsoring firms to predict bankruptcy.
   - Determined if the T-PIMS model incorporates industry-specific factors or data to predict bankruptcy probabilities.
2) Alignment of Data Inputs and Assumptions
   - Flagged any mismatches in inputs to identify any drivers of key differences.
   - Compared underlying model assumptions to identify any drivers of key differences.
   - Compared metrics utilized across models to ensure consistent definitions are used for proper comparison.
   - Analyzed the impact of the economic scenario generator (ESG).
3) Model Results Comparison
   - Compared the percentage of investment grade plan sponsors.
   - Compared the annual and cumulative predicted rates of bankruptcy for sponsoring firms generated by T-PIMS and Legacy PIMS bankruptcy models.
   - Conducted root cause analysis on differences larger than 5% between T-PIMS and Legacy PIMS bankruptcy models' outputs.

Comparison of Structural Differences

Major Structural Differences

The Legacy PIMS and T-PIMS bankruptcy models differ vastly in their construction and functional form. While the central goal remains the same, PBGC considered a wide variety of approaches to modeling bankruptcy. Since the initial development of the Legacy PIMS bankruptcy model over two decades ago, there have been many advancements in the field for more sophisticated and modern approaches to predicting bankruptcy. These advancements helped shape the development of a more sophisticated bankruptcy model for T-PIMS.

Since T-PIMS was built entirely independently of Legacy PIMS, the bankruptcy models are not intended to reconcile. However, it is intended that T-PIMS will provide an improved prediction of bankruptcies compared to the Legacy PIMS bankruptcy model.

Structure	Legacy PIMS	T-PIMS
Functional Form	Firm-level Logit Regression	Hybrid Merton Model
Output	Single Firm's Probability of Default	Credit Rating Transition Matrix

T-PIMS Bankruptcy Model Description

PBGC designed the new bankruptcy model to generate a credit rating transition matrix using a hybrid Merton model. A credit rating transition matrix shows the probability of a firm with a specific credit rating at the beginning of a period transitioning to a different credit rating (or defaulting) by the end of that period. Default, which often leads to bankruptcy, is the critical endpoint in the credit rating transition matrix. The T-PIMS bankruptcy model predicts the probability of a firm transitioning to a "default" state from any given credit rating. The model is run through 500 scenarios, representing a variety of economic conditions. The model steps include:

- Segmenting firms into five rating buckets based on their S&P CreditPro rating (AAA_AA_A, BBB, BB, B, and CCC_CC_C).
- Estimating default probabilities on firms with a B, CCC, CC, or C credit rating using Ordinary Least Squares (OLS) regression. The dependent variable is a binary indicator between default and non-default, which is then transformed logistically to ensure the outcome is between 0 and 1. From a list of thirteen macroeconomic variables, PBGC ultimately selected three as their default predictors: the S&P 500 returns, High Yield to Investment Grade Spread, and 10-Year to 3-Month Spread.
- Estimating default probabilities for all credit rating buckets using an analytical model. The analytical model assumes the relationship between the rating buckets is proportional. The weighting factor is calculated for each rating bucket using the probability of default for the B_CCC_CC_C bucket and historical default rates for the rating bucket. A probability of default is generated by multiplying the weighting factor and the probability of default for the B_CCC_CC_C category.
- Adjusting initial default probability estimates using the historical average default rates. The refined estimates are then used to generate the projected credit rating transition matrix. This allows the model to take into account historical trends in the forecast.
- Determining if credit rating transitions occur based on each plan sponsor's current credit rating transition probabilities and a random number generated from a [0,1] interval. When a credit rating transition occurs, the plan sponsor's new credit rating will be the first credit rating whose cumulative transition probability exceeds the random number generated.
- In T-PIMS, once a plan is projected to default, the plan is no longer included in projections in subsequent years because any liabilities originating from the projected bankruptcy are accounted for in the year of the bankruptcy.

The reconciliation team identified an error in the FY 2023 files whereby two plans and their associated bundles were not removed from the projections in the years following default. This occurred over multiple economic scenarios. When analyzing the default counts for T-PIMS in FY 2023, this led to default counts becoming artificially high. In discussion with PBGC's Policy, Research, and Analysis Department (PRAD), this issue stemmed from two specific plans having zero cash flows in the model and was addressed in a follow-up run. The default counts in this section of the report reflect the FY 2023 counts with the duplicative default counts removed, but do not reflect the full changes implemented in the follow-up run that addressed the cause of this error given it is beyond the scope of this review. The reconciliation team recommends further checks to ensure the credit transitions reflect the intended model steps.

Legacy PIMS Bankruptcy Model Description

The Legacy PIMS bankruptcy model uses a logit regression model to estimate a firm's probability of bankruptcy. One strength of the Legacy PIMS model is that the logit regression model allows for ease of interpretation. Variables utilized are stochastic in nature, which allows them to have changing bankruptcy probabilities throughout the projection period. PBGC estimates the Legacy PIMS bankruptcy model using sample size weights that reflect the ratio of population-to-sample counts for bankrupt and non-bankrupt firms. The bankruptcy model is applied to each firm over a user-input number of cycles for each economic scenario, typically 10. A typical Legacy PIMS run would include 500 economic scenarios.

The Legacy PIMS bankruptcy is described in the following steps:

- The bankruptcy model estimates a firm-year level logit regression, where the dependent variable is a binary variable signifying if the firm enters bankruptcy in that year. The independent variables are characteristics of a firm's financial health. The model also includes error terms made up of three components: economy-level, industry-level, and firm-level.
- A random draw is made from a uniform distribution over the interval [0, 1], and if the random number is less than or equal to the probability of default, the firm is simulated to default in that year.

For reconciliation purposes, PBGC applied two changes to the Legacy PIMS bankruptcy model.

- The T-PIMS ESG was utilized instead of the original Legacy PIMS ESG. The same macroeconomic parameters were applied.
- The bankruptcy probabilities from the Legacy PIMS bankruptcy model output were transformed into credit ratings using the midpoints between the historic average default probabilities at the bounds of the rating categories with the logit measure.

For more detailed analysis and information on Legacy PIMS, please refer to existing PBGC PIMS Reports and Peer Reviews.

Firm-Level Characteristics

The Legacy PIMS bankruptcy model is designed to predict default for a specific firm in a specific year. As such, variation in firm characteristics, specifically financial conditions, drive the estimation of bankruptcy probabilities.

The independent variables used in the Legacy PIMS bankruptcy model to generate bankruptcy probabilities are all firm-level variables. Over time, additional variables were added to the bankruptcy equation, and the equation was re-estimated. The original independent variables include:

- **Leverage:** Legacy PIMS utilizes the ratio of a firm's market value of debt to its market value of assets to represent a firm's financial health. The log of the equity-to-debt ratio lagged one year and the equity-to-debt ratio, lagged two years, are included in the regression.
- **Cash flow:** Cash flow helps measure the firm's short-run liquidity position. The regression equation uses both the one-year and two-year lagged values of the cash flow-to-asset ratio.
- **Size:** The bankruptcy model also incorporates firm size as measured by the number of employees. This variable is included under the assumption that declines in employees indicate a firm in financial distress and thus has an inverse relationship with default. Further, it is assumed

that larger firms tend to have lower bankruptcy probabilities. The bankruptcy regression includes the lagged log of employment and the log of lagged changes in size.

- **Funding ratio:** This variable is included because the ratio of pension assets to pension liabilities functions as a form of debt for the firm. As such, there is a larger burden for firms with pension underfunding compared to fully funded plans. The model includes the log of the pension funding ratio, which is pension assets divided by pension liabilities.
- **Industry dummy variables:** To better account for structural differences in the relationship between asset-to-debt ratios and bankruptcy across industries, the model includes dummy variables for financial firms and utility firms in the bankruptcy model. Typically, higher asset-to-debt ratios in these two industries are not correlated with high bankruptcy rates.

In contrast, T-PIMS relies on the credit ratings to factor in firm characteristics for estimating firms' default probabilities. PBGC utilizes S&P CreditPro Ratings, which undergo an intensive process of evaluating firms to generate credit ratings. Because the credit ratings are based on S&P Global's quantitative and qualitative analysis of each firm's financial and business outlook, the model captures some of the firm-level variation in default risk associated with their financials. Nonetheless, because credit ratings are ultimately aggregated into rating buckets, the model implicitly assumes that each bucket's average default probability approximates the default probability of the average firm within each rating bucket. This assumption appears reasonable under most circumstances; below, we highlight certain situations where additional adjustments may be necessary to consider correlated defaults whether due to observable factors (industry-specific shocks) or common latent factors ("frailty").

Industry-level Characteristics

Industry-level characteristics can play a crucial role in predicting bankruptcy because firms in the same industry may share common macroeconomic and competitive forces that influence their financial health. Factors such as industry growth rates, technological disruption, and regulatory changes can create systemic risks or opportunities that affect multiple firms within the same industry. Historic PBGC claims also show patterns by industry, whereby over half of all claims from 1975-2023 occur in manufacturing and a quarter of claims occur in transportation and public utilities. This information can be found in the PBGC Pension Insurance Data Tables.

Legacy PIMS incorporates industry-level disturbances for leverage, employment, cash-flow-to-assets, and equity value equations. The segmentation of the error term allowed PBGC to analyze industry-specific trends. The model also incorporates industry factors by including two specific industry-level dummy variables under the assumption that the financial and utility industries have different bankruptcy trends related to asset-to-debt ratio.

T-PIMS does not incorporate industry-level characteristics into the default probability model. Although, industry factors are considered when calculating T4 liabilities resulting from potential default.

Macroeconomic Characteristics

Macroeconomic factors exert a powerful and pervasive influence on bankruptcy risk across all firms. Fluctuations in the overall economy, such as periods of recession or strong growth, directly impact consumer demand, business investment, and profitability. All these factors have implications if a firm will default.

The Legacy PIMS bankruptcy model only incorporates macroeconomic factors directly through the error term. There is an economy-level component of the disturbances for the leverage, employment, cash-flow-to-assets, and equity value equations.
In T-PIMS, macroeconomic variables are independent variables in the regression equation applied to B, CCC, CC, and C rated firms. PBGC tested a variety of explanatory variables for this regression model and decided on the following three variables which are widely used in the field for predicting defaults.

1. **S&P 500 returns:** This variable is included under the assumption that decreased market returns are more likely to precede defaults.
2. **High Yield to Investment Grade spread:** This variable is included under the assumption that an increased number of high yield bonds issued compared to investment grade bonds is a sign of financial distress because firms are trying to raise cash to avoid default.
3. **10-Year to 3-Month spread:** This variable is included to represent investor expectations about the future economic growth. An inverted yield curve (negative spread) has historically been a significant indicator of an upcoming economic recession because it suggests a more pessimistic long-term economic outlook.

Figures 1 to 3 illustrate the individual (partial) relationship between the annual default rates in T-PIMS and Legacy PIMS and the three macroeconomic variables utilized directly in the T-PIMS model using the FY 2023 ESG.[1] The independent variables are lagged by one year, following PBGC's bankruptcy model documentation. The results are consistent with the FY 2022 ESG as well. While the Legacy PIMS model was not fit to these three variables, the reconciliation team wanted to understand how the default counts correlated with the main macroeconomic variables utilized in T-PIMS, especially since these can have substantial impacts on a firm's financial health. The figures represent the strong relationship between the three core explanatory variables of the T-PIMS bankruptcy model and the T-PIMS default counts. These relationships also conform with economic intuition. Specifically, bankruptcy incidence is inversely correlated with stock returns and the slope of the yield curve while also positively associated with the credit spread between high yield and investment grade bonds.

The correlations between the Legacy PIMS default counts and these macroeconomic variables appear limited. In some instances, the relationships even appear counter to intuition; for example, S&P 500 returns appear to be positively, albeit only weakly, associated with the default rates (Figure 1).

One potential explanation for this difference between T-PIMS and Legacy PIMS is that the bankruptcy probabilities in Legacy PIMS are estimated on firm-level characteristics. Thus, changes in macroeconomic variables influence bankruptcy probabilities in Legacy PIMS via their association with firm-level characteristics. Additionally, the Legacy PIMS model incorporates other components in the error term and higher-order lagged values of firm-level characteristics that may weaken the partial linear relationship between (one-year lagged) macroeconomic variables and a firm's default probability. By contrast, changes in these macroeconomic variables have direct and linear impacts on default probabilities in T-PIMS. Furthermore, the Legacy PIMS bankruptcy model models equity-to-debt and cash flow-to-assets using a mean reversion model. In the transformation of bankruptcy probabilities to credit ratings, the mean reversion terms may have led to a high amount of bundling around the middle

[1] This is done by plotting the residuals from the regression of default rates on the two variables other than the variable of interest against the residuals from the regression of the variable of interest on the same two variables.

credit rating categories (i.e., BB and BBB), which resulted in a less dispersed distribution of the credit transitions and less variability in the transitions. These modeling differences and the sensitivity of T-PIMS to macroeconomic factors could be an explanation for the difference in annual default rates between T-PIMS and Legacy PIMS discussed later in this report.

Figure 1. Relationship Between Stock Returns and Default Rates for Legacy PIMS and T-PIMS (FY 2023)

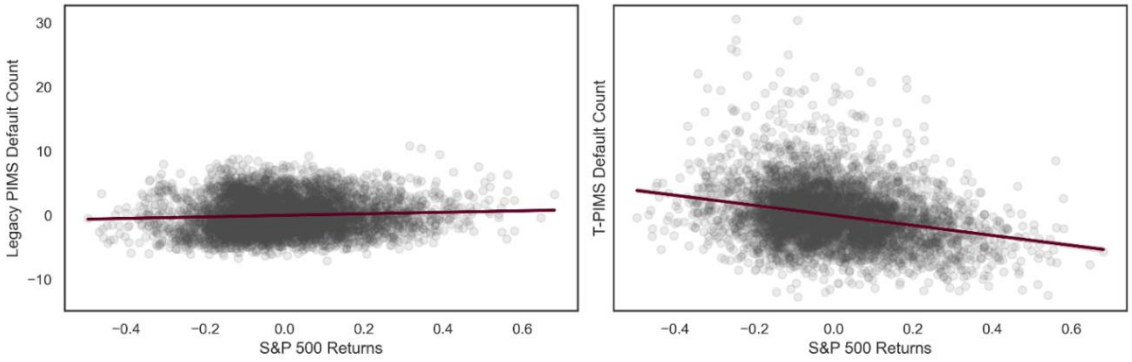


Figure 2. Relationship Between High Yield to Investment Grade Corporate Bond Spread and Default Rates for Legacy PIMS and T-PIMS (FY 2023)

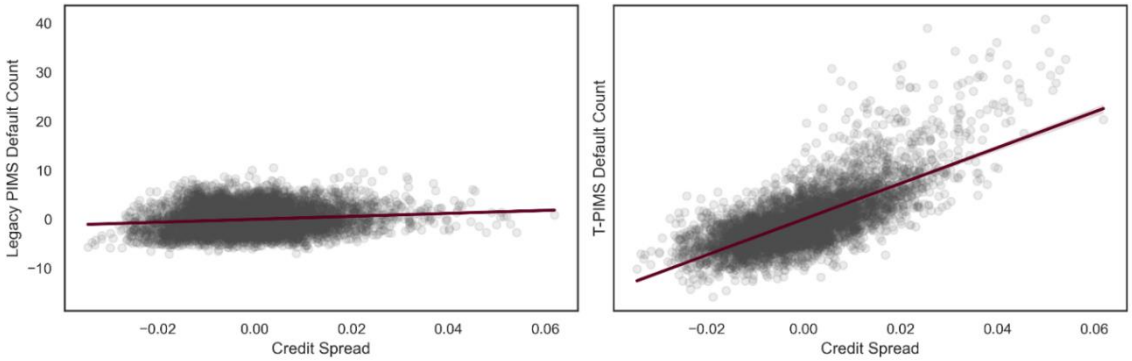
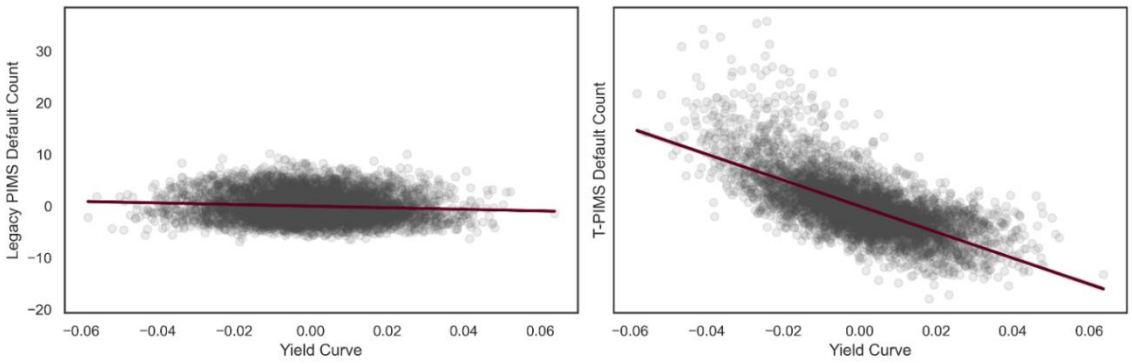


Figure 3. Relationship Between Treasury 10-Year to 3-Month Spread and Default Rates for Legacy PIMS and T-PIMS (FY 2023)



Note: The graphs above show the residualized linear relationship between default rates in Legacy PIMS and T-PIMS and each applicable macroeconomic variable.

Alignment of Data Inputs and Assumptions

Metric Consistency

To ensure a meaningful reconciliation between the two models, the reconciliation team verified the metrics were consistent. This involved a detailed examination of definitions, calculation methodologies, and underlying assumptions for each metric used. The reconciliation team confirmed that metrics with the same name represented the same underlying concept, accounting for any potential variations in data sources or processing steps. This process of aligning metric definitions and calculations ensured that any observed differences in model outputs could be attributed to genuine variations in their predictive capabilities rather than inconsistencies in how the metrics themselves were defined and measured, thus preventing misinterpretations during the reconciliation process. Any identified differences are noted below.

- **Default probability:** The likelihood that a firm will default in a given year. In Legacy PIMS, the default probability is projected at the firm level. In T-PIMS, the default probability is projected at the credit rating category level.
- **Annual default rate:** The ratio between the number of firms projected to default each year to the total number of firms rated at the beginning of the year.
- **Cumulative default rate:** The ratio between the total number of firms projected to default in the projection period to the total number of firms rated at the beginning of the projection period.
- **Annual default rate (without de-risking):** The ratio between the total number of firms projected to default each year to the total number of firms, including voluntary standard terminations.
- **Cumulative default rate (without de-risking):** The ratio between the total number of firms projected to default in the projection period to the total number of firms, including voluntary standard terminations.
    - **Standard Terminations:** There are two types of standard terminations: voluntary terminations with plan funding level above 80%, and terminations initiated by a projected bankruptcy model with plan funding above 80%. The first type of termination is unrelated to the bankruptcy model and handled differently by T-PIMS and Legacy PIMS. In T-PIMS, the voluntary terminations are removed from subsequent projections. However, in Legacy PIMS, they are imputed with a credit rating as if they were not terminated. This difference in the treatment of voluntary terminations implies that some plans which have been removed from projections in T-PIMS may be present in Legacy PIMS. In the FY 2023 T-PIMS, about 6.7% of the 593,500 (500 × 1,187) plans end up as standard terminations between 2025 and 2034. Standard terminations related to a bankruptcy draw are assigned to the D credit rating category in T-PIMS and Legacy PIMS.
- **Credit ratings:** A credit rating bucket to indicate an obligator's capacity to meet its financial commitments to an obligation. Since Legacy PIMS output was transformed into credit rating buckets, the comparison of credit ratings between the two models is not intended to be exact.
- **Investment grade:** A categorization of an obligation's quality. Investment grade includes obligations graded AAA, AA, A, or BBB. Non-investment grade includes obligations graded BB, B, CCC, CC, or C.
- **T4 Liability:** The estimated total amount of money PBGC would be responsible for paying out in the future if the plan-sponsor were to default. If a termination occurred whereby a plan is above 80% funding and is not trusteed by PBGC, the T4 liability is $0 because this is considered a standard termination.

Economic Scenario Generators

For model comparison, PBGC utilized the same ESG for Legacy PIMS and T-PIMS runs for FY 2022 and FY 2023. The current ESG is sourced from a third-party in the interim while PBGC develops their own internal ESG for T-PIMS. We compared the ESG to historical data to validate the reasonability of the macroeconomic inputs used in the model as well as how changes in the inputs result in changes in both bankruptcy models.

Figures 4-6 show the historical trends in the three independent variables utilized in the regression model and their projected values across the 1st, 15th, 50th, 85th, and 99th percentiles.

- **S&P 500 Returns** (Figure 4): The projected S&P 500 returns seem reasonable given historical data. The 1st-99th percentiles cover most peaks and troughs since 1927. However, it is notable that the economic environment pre-1980 was vastly different to post-1980, with high inflation, protectionist trade policies, and increased global conflicts. Since pre-1980 geopolitical trends may become more realistic in the near-term, it is recommended to consider how various regimes within the ESG consider these potential policy levers in the economic environment. For example, it may be helpful to introduce regimes that reflect "stagflationary" environments with low growth rates, high unemployment, and high inflation, which occurred during the 1970s in the United States.
- **High Yield to Investment Grade Spread** (Figure 5): The projected high yield to investment grade spread seems substantively low compared to historical patterns. This trend may require some additional investigation to ensure the projected values represent a realistic view of high yield to investment grade spread, even across a variety of economic conditions.
- **10-Year to 3-Month Treasury Spread** (Figure 6): The projected Treasury spread is reasonable given historical data.

Figure 4. S&P 500 Historical and ESG Projection (1926 – 2043)

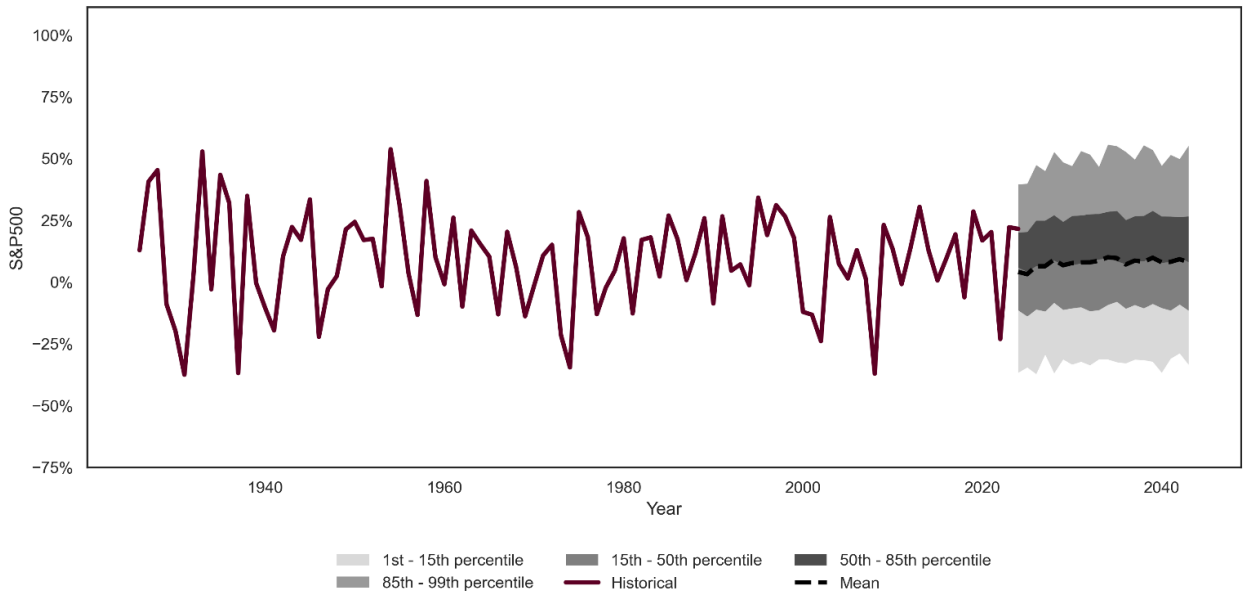


Figure 5. High Yield to Investment Grade Spread Historical and ESG Projection (1996 – 2043)

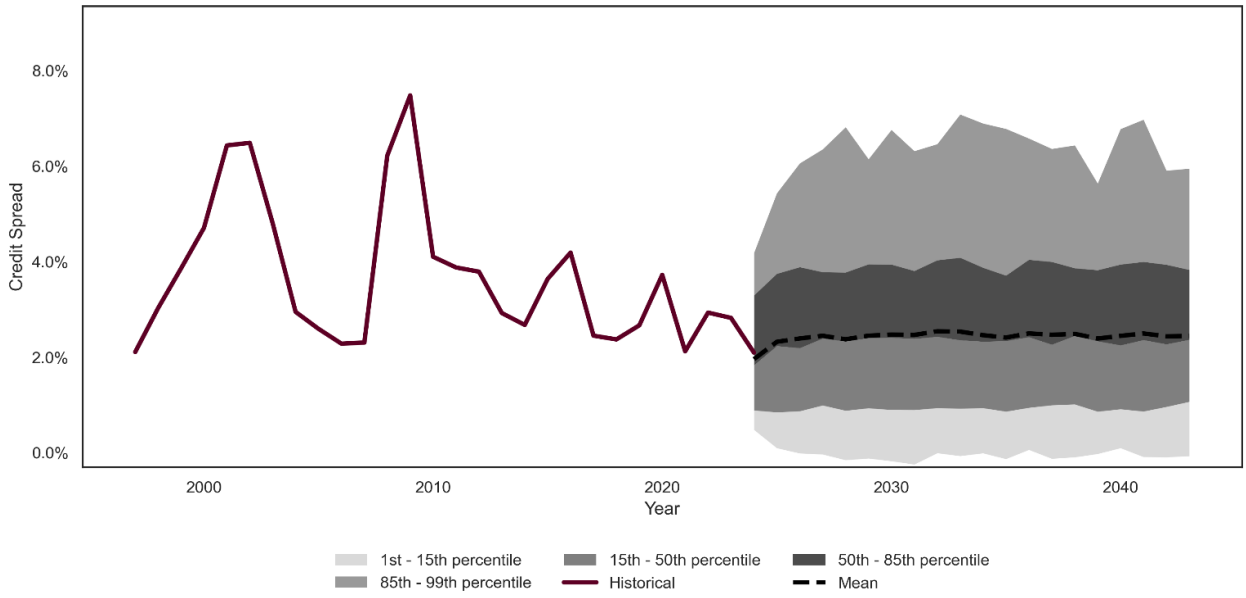
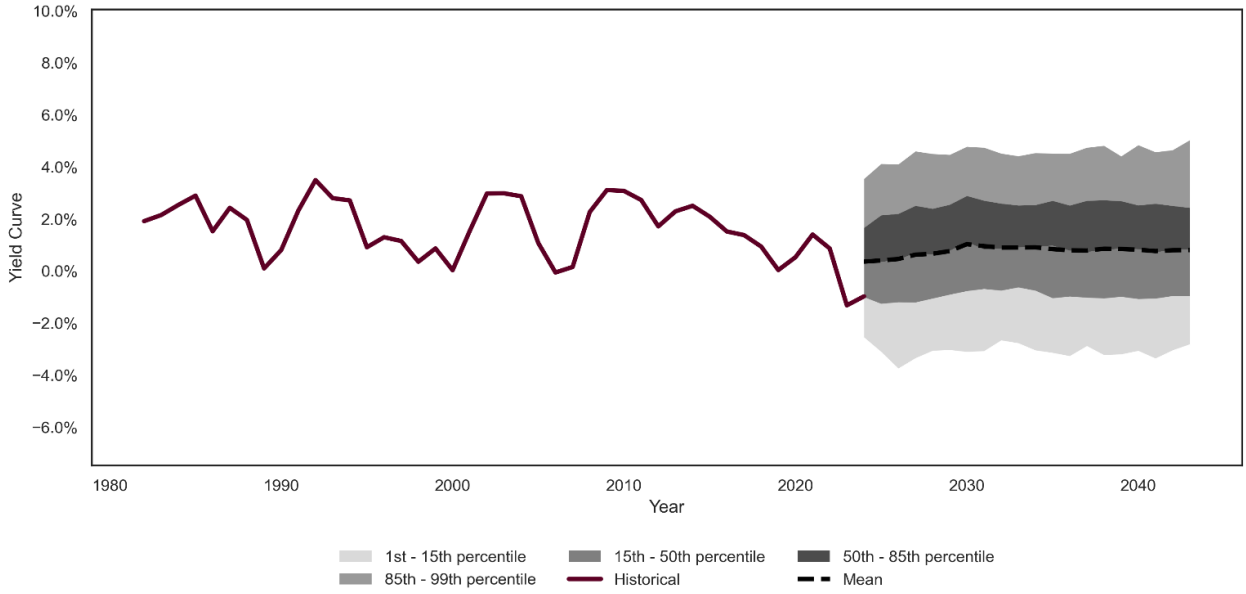


Figure 6. Treasury 10-Year to 3-Month Spread Historical and ESG Projection (1982 – 2043)



Note: In FY 2023 ESG data, Year 0 is assigned 2023. Historical data includes 2024.

The reconciliation team compared the ESG projections between FY 2022 and FY 2023 to better understand how changes in the ESG impact projected default rates (Table 1). The FY 2023 ESG projections no longer show an inverted yield curve in the short-term, indicating lower recession risk compared to FY 2022. In FY 2023, there are lower high yield to investment grade bond spreads, especially in the near term. There is also less dispersion in equity returns in the short- to medium-term.

Table 1. Summary Statistics of ESG Variables (Percent Difference) Between FY 2022 and FY 2023

	High Yield to Investment Grade Spread	Treasury 10-Year to 3-Month Spread	S&P 500 Returns
Mean	-2.8	87.6	-0.8
StdDev	0.8	-4.1	-4.2
p1	-112.5	14.4	1.3
p15	-7.6	31.1	2.7
p50	-4.0	93.8	5.5
p85	-2.1	12.7	-3.9
p99	3.4	2.6	-4.9

Note: Light orange highlights indicate the magnitude of the FY 2022-FY 2023 percent difference exceeds 2 percent, while dark orange highlights indicate magnitudes greater than 5 percent.

These changes in ESG variables are consistent with the changes we see in default rates between FY 2022 and FY 2023, which shows how T-PIMS is impacted by changes in economic scenarios and conditions. The movement in default rates between FY 2022 and FY 2023 is consistent with what is expected based on the changes in the ESG. In FY 2023, T-PIMS shows decreased annual and cumulative default probabilities compared to FY 2022 (Figure 7). This is due to a more positive economic outlook in the ESG variables compared to FY 2022, which resulted in a slightly larger proportion of investment grade plans (Figure 8). The changes shown from FY 2022 to FY 2023 in T-PIMS signal a reasonable shift given the changes in input values from the ESG.

Figure 7. Change in Annual and Cumulative Default Probabilities for T-PIMS (FY 2022-FY 2023)

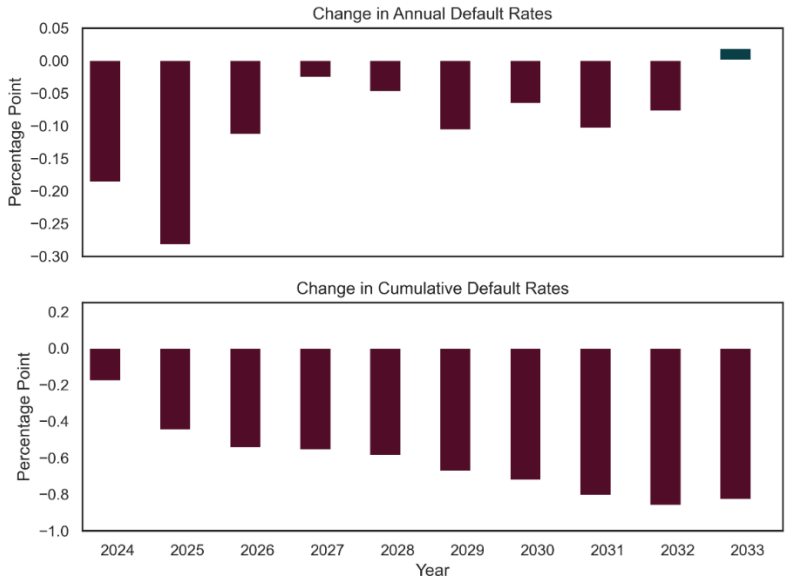
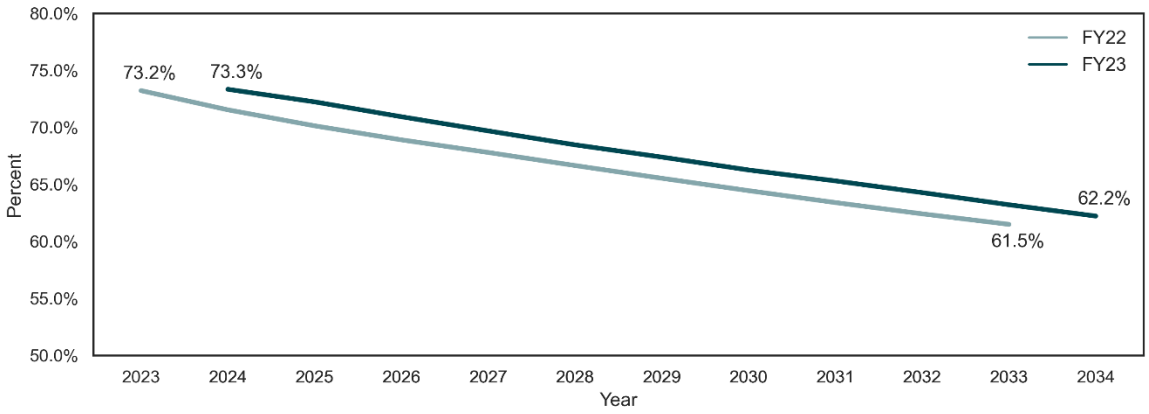


Figure 8. Portion Projected Investment Grade (Without De-risking) for T-PIMS (FY 2022-FY 2023)



Model Results Comparison

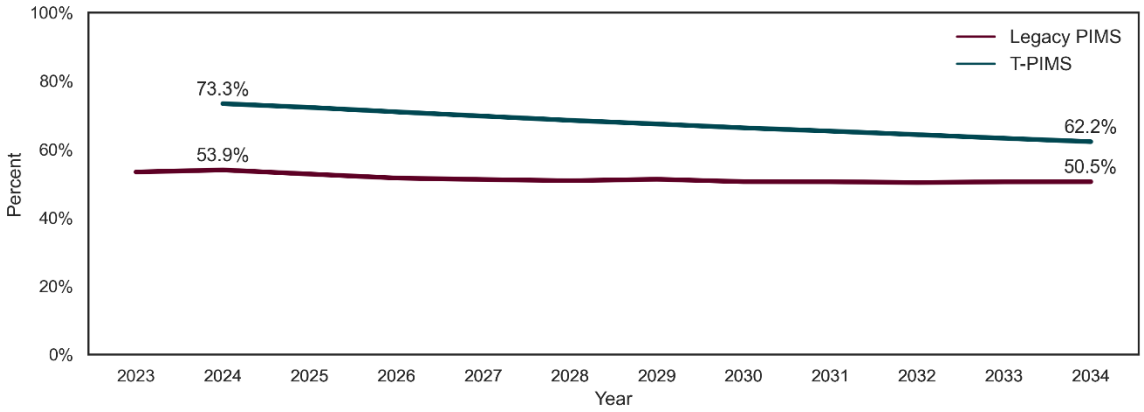
Reconciliation Results

PBGC transformed the Legacy PIMS bankruptcy model results into the credit rating transition matrix format of T-PIMS to facilitate reconciliation. Due to this transformation, the reconciliation between the two bankruptcy models is not intended to be precise. The reconciliation team was provided bankruptcy results from FY 2022 and FY 2023. Given that trends across FY 2022 and FY 2023 were quite similar, the reconciliation team's analysis below focuses on FY 2023 results. Any substantial differences between FY 2022 and FY 2023 are noted. These reconciliation results reflect the data provided to the reconciliation team and may not reflect updated runs.

Investment Grade

Investment grade plans are based on credit rating, which for Legacy PIMS is imputed because the model does not natively utilize credit ratings. T-PIMS has a larger share of plans with a credit rating considered investment grade (i.e., AAA, AA, A, or BBB) compared to Legacy PIMS based on plan count. The difference in FY 2023 is 19.4 percentage points (pp) at the beginning of the projection period and slowly shrinks over the projection period to a gap of 11.7pp (Figure 9). The higher share of investment grade coupled with the higher default rate in T-PIMS indicates how the hybrid Merton model results in higher variability of defaults for all plan sponsors, including those with higher ratings. The differences between Legacy and T-PIMS can also be partially explained by differences in how voluntary standard terminations are represented.

Figure 9. Percentage of Projected Investment Grade Plans (Without De-risking) for Legacy PIMS and T-PIMS (FY 2023)



Default Rate

Overall Default Rate (Without De-risking)

The main output of the bankruptcy model is to project which firms will default, thus potentially leading to PBGC claims from the pension plans sponsored by the defaulting firms. The differences between the T-PIMS and Legacy PIMS default rate (without de-risking) is substantial. The two models are significantly different in annual and cumulative default rates (without de-risking) at nearly every point in the distribution, even during the initial years in both the FY 2022 and FY 2023 projections (Table 2). In 2034, Legacy PIMS has a mean annual default rate of 0.49%, and T-PIMS has a mean annual default rate of 0.86%. The mean percent difference in annual default rate between the two models ranges from -15% to 75% in FY 2023. The average cumulative default rate for T-PIMS is higher than Legacy PIMS initially and the gap continues to grow throughout the projection period (Appendix: Figure 45). In 2034, the average cumulative default rate is 9.9% in T-PIMS compared to 6.5% in Legacy PIMS. The 99th percentile in 2034 for cumulative default rate was 21.7% in T-PIMS compared to 8.3% in Legacy PIMS. As seen in Figure 12, the spread of the T-PIMS cumulative default rates is much more dispersed compared to the Legacy PIMS default rates. This shows larger tails for more extreme default rate scenarios. T-PIMS is more likely than Legacy PIMS to predict more extreme default behavior that may produce a sudden spike in claims for PBGC. There are larger tails in T-PIMS, but across the distribution, T-PIMS still generates higher default rates compared to Legacy PIMS. Over time, there is a leftward shift of annual default count in the distribution for both models, but T-PIMS maintains the fatter tails (Figure 10).

The larger tails of the T-PIMS distribution for cumulative default rate reflect how T-PIMS generates a wider set of potential scenarios compared to Legacy PIMS. Given the high default rates projected in the upper percentiles, PBGC may be better equipped to understand the fiscal impacts of severely adverse economic conditions with T-PIMS compared to the Legacy PIMS model. Compared to historical data (~40 years), the number of economic simulations generated from the ESG are over ten-fold (500 bankruptcy scenarios) and as such, it is reasonable to expect that the Legacy PIMS and T-PIMS bankruptcy models will be subject to a wide range of economic scenarios, many of which have not

occurred in recent history. As seen in Figures 10 and 11, the T-PIMS bankruptcy model is much more sensitive to these varied economic scenarios compared to Legacy PIMS, leading to a wider range of projected default rates.

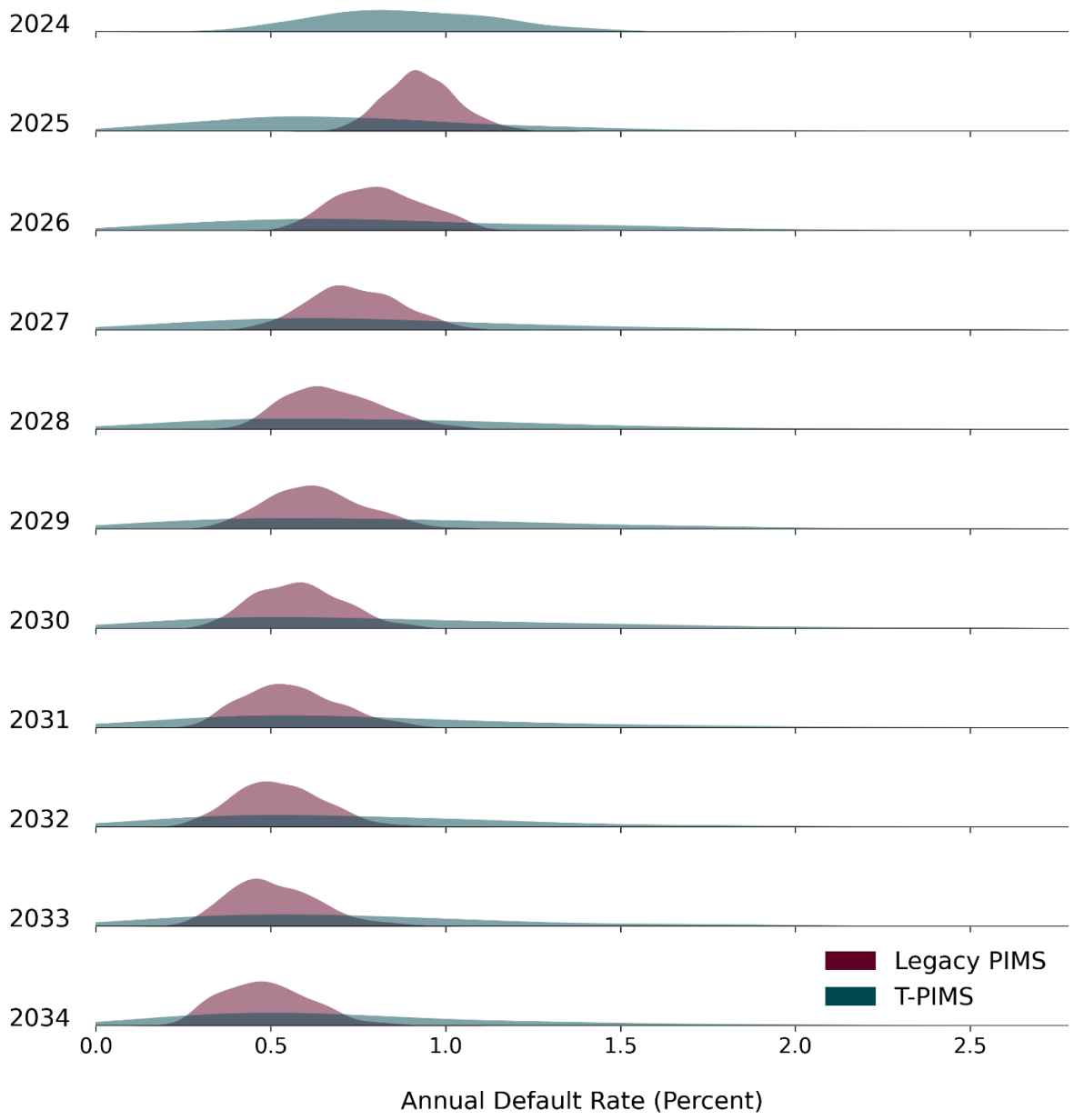
Table 2. FY 2023 Annual Default Rate (Without De-risking) Comparison as Percent Difference Between Legacy PIMS and T-PIMS

	Mean	p1	p15	p50	p85	p99
2025	-15.6	-88.2	-59.0	-27.0	22.5	75.5
2026	12.9	-84.8	-50.0	-6.3	58.4	149.9
2027	29.2	-81.8	-44.5	3.6	73.1	237.9
2028	40.3	-80.4	-37.4	26.8	82.6	232.6
2029	45.9	-100	-30.6	22.2	93.6	176.0
2030	58.8	-74.5	-25.4	30.7	121.9	285.1
2031	58.3	-72.2	-18.1	23.4	102.3	335.6
2032	66.1	-100	-13.8	31.5	114.5	307.0
2033	73.9	-100	-34.2	36.9	134.3	351.7
2034	74.5	-100	-27.9	40.8	125.9	296.5

Note: Light orange highlights indicate the magnitude of the Legacy PIMS-T-PIMS percent difference exceeds 2 percent, while dark orange highlights indicate magnitudes greater than 5 percent. A negative percent difference indicates a lower value in T-PIMS compared to Legacy PIMS. For T-PIMS, n=1187. For Legacy PIMS, n = 1483.

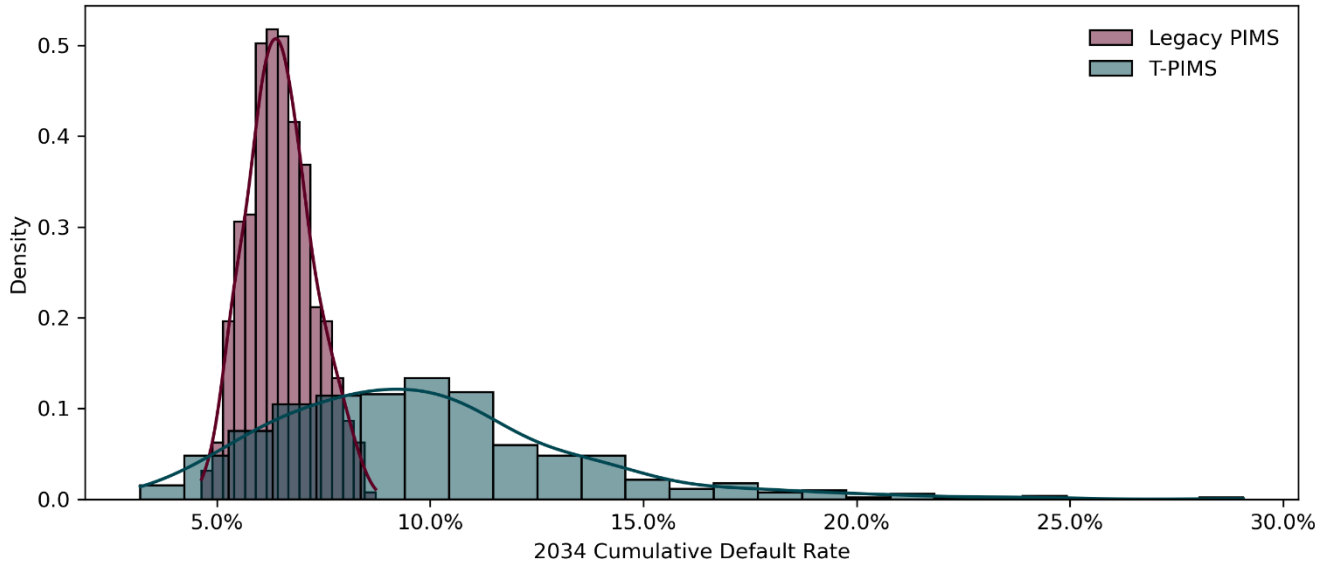
The differences in annual default rate showcase the structural differences between Legacy PIMS and T-PIMS. In the Legacy PIMS bankruptcy model, the logit model is applied to all firms within the sample. While sampling techniques are one of the major differences between the two models overall, the logit model being applied to all firms within the sample is significant because bankruptcies are historically uncommon across all firms. This contrasts with the T-PIMS approach, where bankruptcies are estimated on the sub-group of the sample most likely to experience defaults and then monotonically scaled to the rest of the sample by credit rating group. The lower rated firms, especially those in the B_CCC_CC_C rating bucket, are likely the ones that are most sensitive to adverse economic conditions. Their sensitivity to macroeconomic downturns may be transferred to other credit ratings via the analytical model.

Figure 10. Annual Default Rate for Legacy PIMS and T-PIMS (2024-2034)



Note: For readability, the x-axis is truncated at the 99th percentile of annual default rates (2.78 percent) across both Legacy PIMS and T-PIMS. That is, 110 scenario-year observations are excluded in the figure. Their exclusion has no material impact on the interpretability of the figure, which focuses on comparing the annual default rate distribution between the Legacy PIMS T-PIMS.

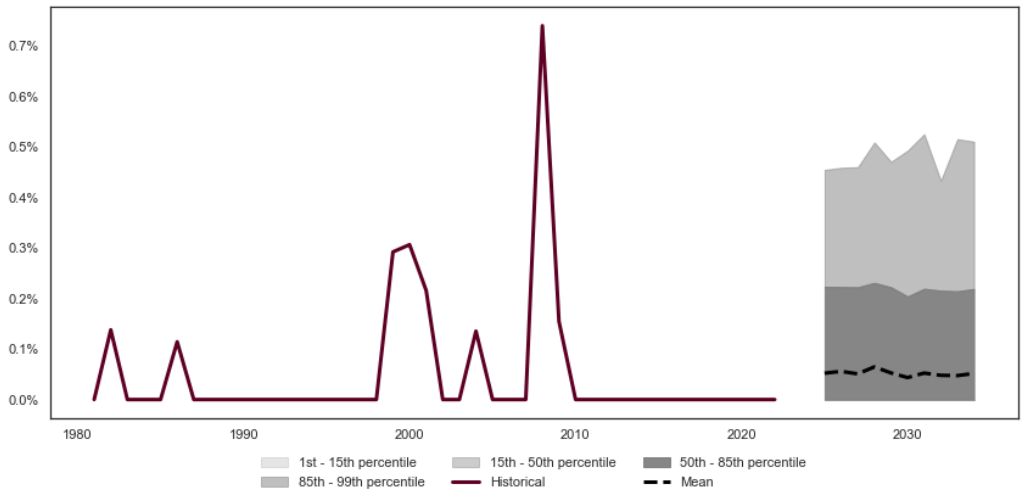
Figure 11. Cumulative Default Rate Histogram (2034) for Legacy PIMS and T-PIMS



Default Rate by Initial Credit Rating

The reconciliation team reviewed the historical credit rating transitions to default with T-PIMS credit rating transitions to default based on initial credit rating. For the AAA_AA_A credit rating bucket, T-PIMS projects a distribution that covers nearly all spikes of defaults of AAA, AA, or A-rated firms over the past 40 years (Figure 12). The largest spike in the historical period for AAA, AA, or A-rated firms occurred in 2008. The mean default rate, or the rate of simulated defaults, for firms in the AAA_AA_A bucket in 2034 is 0.05%, while the 50th percentile is 0% and the 99th percentile is 0.5%. While there are some scenarios in the projection whereby AAA_AA_A rated firms are projected to default, it is rare in T-PIMS.

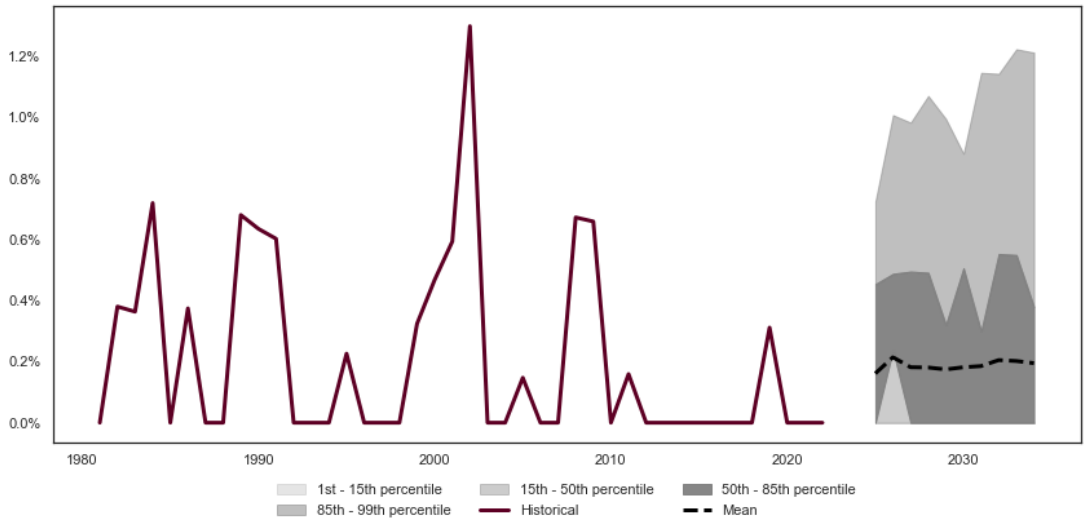
Figure 12. AAA_AA_A Historical and T-PIMS Transition to Default (FY 2023)



Note: For the AAA_AA_A credit rating bucket, the 1st and 15th percentiles across all years have an annual default rate of 0%.

For credit rating bucket BBB, BB, and B, the distribution of projected defaults seems relatively well calibrated to historical default rates. The average default rate for BBB firms in 2034 is 0.2%, the 50th percentile is 0%, and the 99th percentile is 1.2% (Figure 13). The average default rate for BB firms in 2034 is 0.8%, the 50th percentile is 0.7%, and the 99th percentile is 3.9%. The average default rate for B firms in 2034 is 3.7%, the 50th percentile is 3.0%, and the 99th percentile is 15.3%. Figures for BB and B firms can be found in the Appendix (Figures 46 and 47).

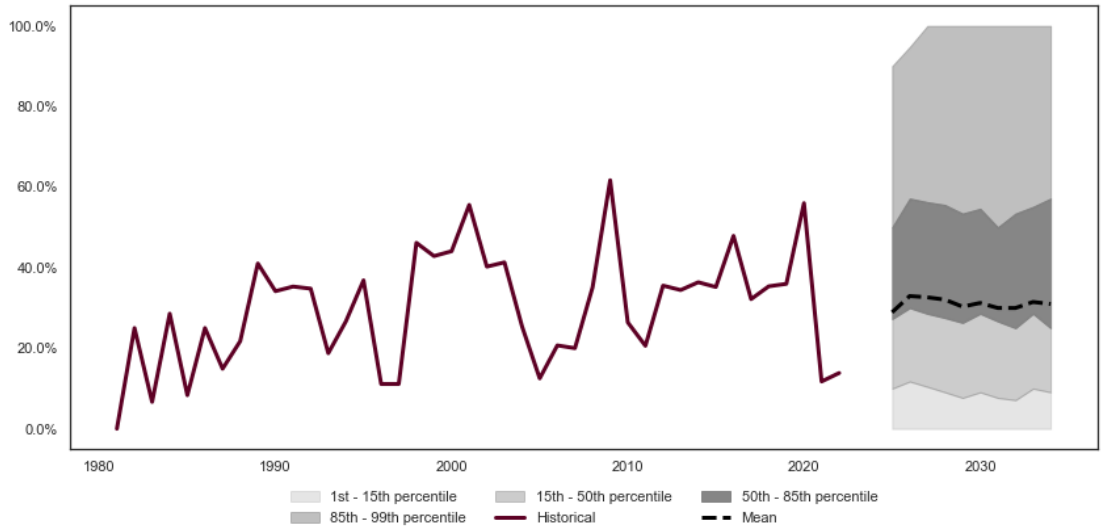
Figure 13. BBB Historical and T-PIMS Transition to Default (FY 2023)



Note: For the BBB credit rating bucket, the 1st and 15th percentiles across all years of the projection have an annual default rate of 0%.

For credit rating bucket, CCC_CC_C, the distribution of projected annual defaults in T-PIMS is quite large, covering all historical spikes of default since 1981 (Figure 14). The 99th percentile of projected annual defaults in 2027 to 2034 is 100%. While T-PIMS adequately captures a wider distribution of default possibilities compared to Legacy PIMS, these tail events may be generating a more conservative financial outlook for PBGC. The average default rate for firms rated CCC, CC, or C in 2034 is 31.0%, and the 50th percentile is 25.0%.

Figure 14. CCC_CC_C Historical and T-PIMS Transition to Default (FY 2023)



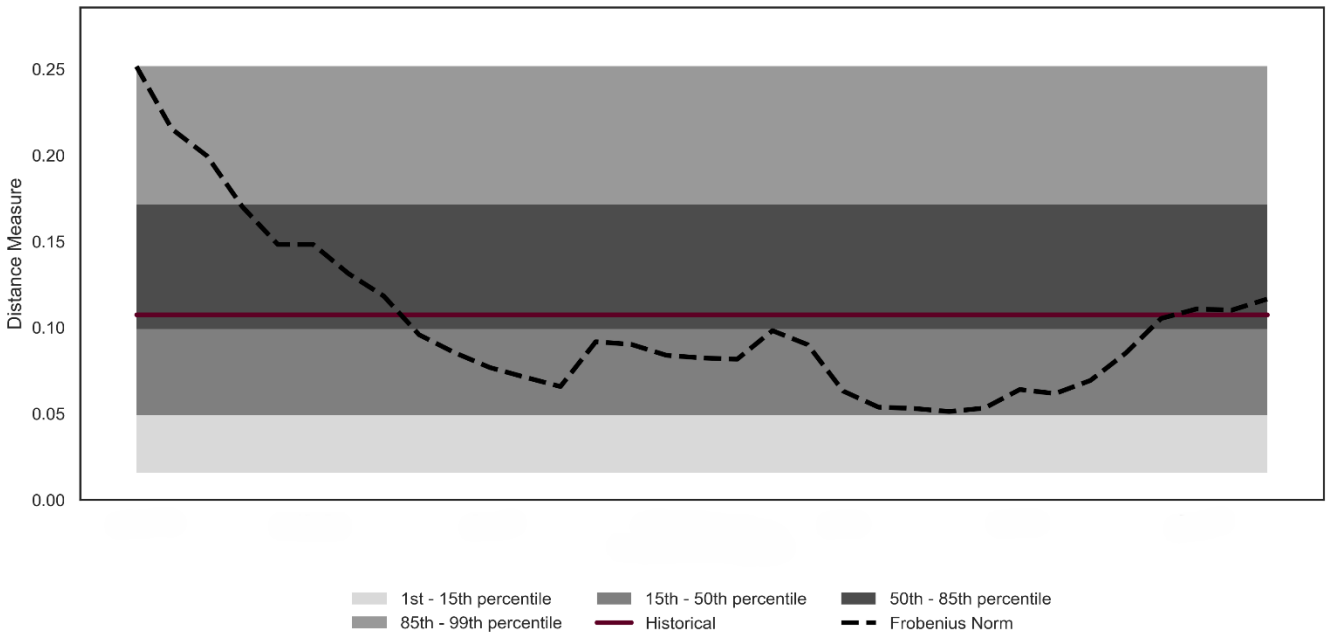
Credit Rating Transition

The reconciliation team compared the projected credit rating transitions from T-PIMS to historical values. For the analysis, the reconciliation team employed the 1980-2022 S&P credit rating transition matrices and FY 2023 T-PIMS credit transition matrices (excluding transitions to default). The evaluation proceeds as follows. First, the reconciliation team created 10-year rolling averages of historical credit rating transition matrices and a 10-year average of FY 2023 T-PIMS credit transition matrix. Second, the reconciliation team created a dissimilarity index – based on the Frobenius norm – as a way to evaluate the relative similarity of two matrices.[1] The index is created by dividing the calculated norms by its mean over the historical period such that a value of one indicates an equality between the calculated value and the historical mean of the pairwise difference.

Two observations emerge from Figure 15. First, the T-PIMS credit transition matrices are relatively stable during the forecast period: The maximum of the dissimilarity index over the forecast period is 0.33, or 33 percent of the mean Frobenius norm from all possible decadal combinations from 1980 – 2022. Second, the dissimilarity index falls between the 1st and 99th percentiles for all periods, indicating that projected credit rating transitions in T-PIMS appear reasonable compared to the historical data.

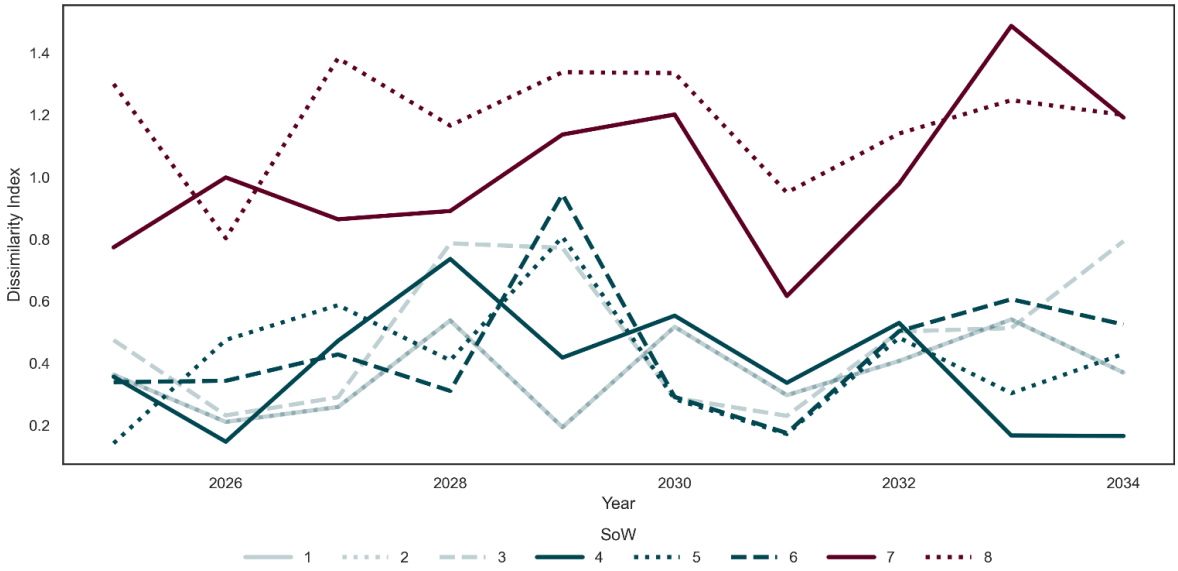
[1] The Frobenius norm is calculated by taking the square root of the sum of the squares of all its elements. A smaller Frobenius norm value indicates two transition matrices are more similar than two with a larger value.

Figure 15. FY 2023 Projection Results for 2025 – 2034 Compared to Average Credit Rating Transitions and Historical Credit Rating Transitions



The reconciliation team also generated the average difference from a pairwise comparison of the credit rating transition matrices grouped by year and state of the world (SoW), which comes from the ESG. In the ESG, each SoW represents a set of underlying economic assumptions that capture the dynamics of the macro variables over the projection period. By incorporating this variable and allowing different SoWs to be realized enables the model to capture abrupt changes in macroeconomic variables. This adds an element of realism to the model since abrupt changes are important to capture sudden policy changes or financial crises. SoW 7 and 8 appear to be distinct from other SoWs, while the others seem relatively similar to each other (Figure 16). Overall, the dissimilarity indices are no larger than 1.6 across SoWs. For comparison, the historic 85th percentile for the dissimilarity index would be around 1.7. This shows that the credit rating transition matrices generated across different SoWs do not differ substantially in T-PIMS. Some research indicates that credit transition matrices are distinct during expansionary and recessionary periods (Bangia et al., 2002). PBGC could consider additional SoWs or other adjustments to capture a wider range of credit rating transition probabilities, as discussed in the Future Considerations section.

Figure 16. Difference in Credit Rating Transition Matrix by Year and SoW (FY 2023)

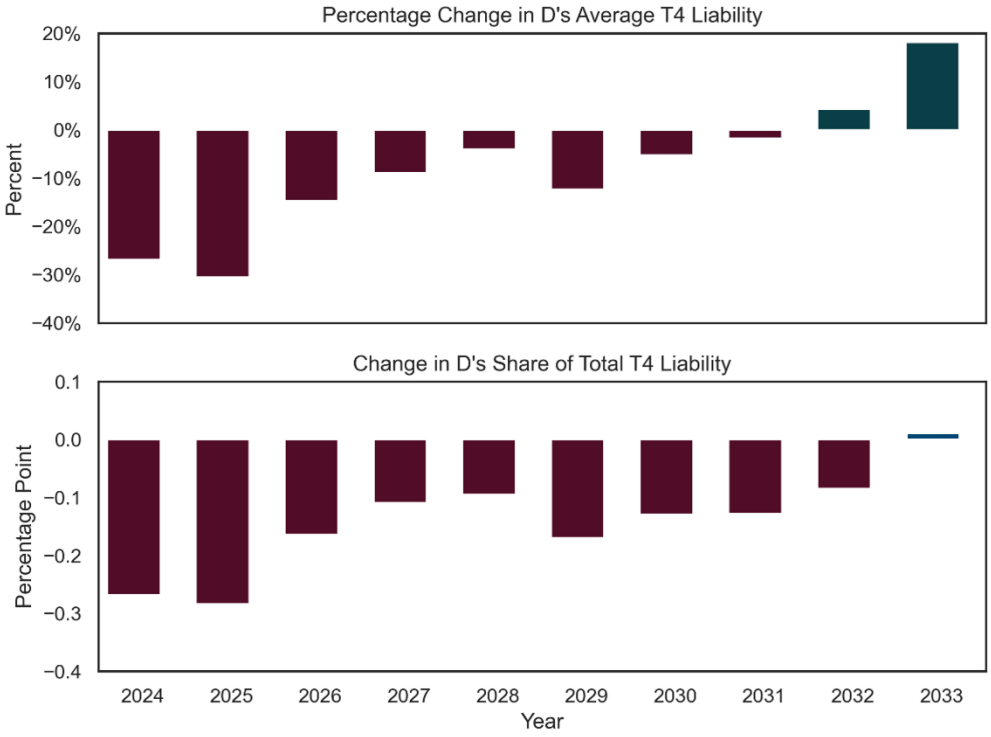


T4 Liabilities

The reconciliation team analyzed T4 liabilities for the plans that are projected to default in the T-PIMS projection. This reflects the plans that are projected to default and their size (in terms of liabilities) that PBGC would then be liable for through claims. Beyond only default rates, T4 liabilities provide insight into the types of plan sponsors that are projected to default between the two models.

To understand the relationship between T4 liability and default, the reconciliation team compared the average T4 liability for the D credit rating bucket between FY 2022 and FY 2023 for T-PIMS. Given that FY 2023 showed lower default probabilities compared to FY 2022, the decrease in T4 liabilities aligns with that trend (Figure 17). The difference in T4 liabilities in the first two years of the projection are large at 27.0% and 31.0%, respectively. The decrease in defaults is also largest in the first two years of the projection. Over time, this gap diminishes and in 2033, FY 2023 results show a higher default rate (0.89% for FY 2023 compared to 0.86% for FY 2022) and slightly larger T4 liability.

Figure 17. Change in T4 Liability for D Credit Rating Bucket between FY 2022 and FY 2023



Note: In 2033, the change in D credit rating bucket's share of total T4 liability is slightly positive, but its value is close to zero (0.001481pp).

Future Considerations

As PBGC continues to refine the T-PIMS bankruptcy model for launch in FY 2025, PRAD may consider the following extensions.

Bankruptcy Model

Credit Ratings as Measure of Default

One of the key tenets of the T-PIMS bankruptcy model is the use of credit rating transition matrices. While this seems to be a reasonable way to predict default as well as a more streamlined way to incorporate firm-level characteristics, there are some limitations to consider with their use. The issuer-pays business model of credit rating transitions can introduce biases, which raise questions about the data's reliability, particularly if ratings are elevated (Bolton et al., 2012). In the case of T-PIMS, a higher credit rating will substantially lower the probability of default, which could lead to an underestimation of defaults if ratings are inaccurately elevated. Additionally, credit rating agencies are more likely to understate credit risk in booms than in recessions, which could lead to an overestimation of default rates during positive economic times. Additionally, credit rating agencies attempt to balance accuracy and stability to reflect enduring changes in credit risk, but this may also lead to a lag behind firms' actual year-to-year financial performance (Altman & Rijken, 2004). Given that credit ratings are a critical input into the bankruptcy model, the reconciliation team recommends PBGC periodically review firms' credit ratings alongside their financial data to ensure continued accuracy and relevance.

Credit Cycles and Correlated Defaults

By utilizing rating categories to assign sponsors' default probabilities, T-PIMS introduces a strong correlation among sponsors' default probabilities, specifically for sponsors within each rating category as they share the same probabilities of default. This change may allow the model to better capture fat-tailed or clustered default events during periods of stress.

Industry shocks serve as a clear illustration of how correlated defaults can occur within a specific sector. An industry shock is a sudden, significant, and often negative event that impacts the overall operating environment and profitability of firms within a particular industry. These shocks can take various forms, such as demand, supply, regulatory, or technological disruption. Industry effects have been shown to be important for bankruptcy prediction (Chava & Jarrow, 2004) and PBGC may consider incorporating more industry-level factors, such as a firm or industry specific beta, into the bankruptcy model. To refine the model, PBGC could introduce industry-specific adjustments that allow for heterogeneous responses to changes in macro conditions (e.g., credit cycles) within the same credit rating category. For instance, the model could differentiate between cyclical versus non-cyclical or financial versus non-financial sectors within each rating bucket. Another possible refinement, which is more complex and data-intensive, would be to consider unobserved, latent factors ("frailty") (Duffie et al., 2009).

Defaults and Recovery Rates

T-PIMS allows the user to assign a uniform fixed recovery rate to each plan, which affects the calculation of plan and PBGC liabilities. Literature shows that traditional credit risk models often neglect the dynamic link between recovery rates and default rates, especially during economic downturns. This oversight can lead to inaccurate risk assessments and potential underestimation of losses. There is an inverse relationship between the probability of default and recovery rates. When a firm's value increases, its default probability tends to decrease, while the expected recovery rate at default increases.

PBGC could consider incorporating a stochastic recovery rate influenced by firm-level or macroeconomic factors, enabling the model to better capture this dynamic relationship. Altman et al., (2005) emphasize that accurately estimating potential losses, and thus PBGC's liabilities, requires recognizing the negative correlation and cyclical nature of these variables. One possible approach is to use the same ESG variables for modeling both defaults and recovery rates.

Evaluation of T-PIMS Model Reliability

In reconciling Legacy PIMS and T-PIMS bankruptcy models, the reconciliation team finds the T-PIMS bankruptcy model to be a reasonable advancement, demonstrating improved ability to represent sudden and impactful shocks through a wider dispersion of bankruptcy results. The T-PIMS results are economically intuitive and move in predictable ways based on economic inputs. However, the results may lead to a more conservative approach given the T-PIMS bankruptcy model generates more tail scenarios. We observed that there tends to be a higher probability that the T-PIMS model overestimates firm defaults, and thus PBGC claims, than that it underestimates firm defaults. We do not find the results unreasonable, but the fit to historical experience should be closely monitored. PBGC may consider additional extensions to the model as further refinements are made to the current iteration.

Modeling the SE Plan Universe

Introduction

In order to accurately project plan results, each model must first attempt to accurately represent the entire SE Plan Universe. The reconciliation team first reviewed the process employed by each model to represent the Plan Universe to gain a comprehensive understanding of any fundamental differences that could be driving the differences in the actuarial model outputs. Below are summaries of the methodology performed for each model, comparisons of the models versus the actual SE Plan Universe, and conclusions and recommendations for future improvements.

Comparison of Structural Differences

Legacy PIMS Methodology

The Legacy PIMS model uses a sample set of actual plan data from over 500 of the largest SE plans from over 300 firms. This sample accounts for over half of PBGC's insurance exposure in the SE defined benefit system. Weighting is applied to the sample set to scale up to represent the full universe of PBGC insured SE plans. Our understanding of the process is below:

- For companies with multiple covered plans, all plans are placed in the same funding status band based on the largest plan's funding status band.
- The funding band widths range from 50% to 150% in 10% increments. Any plans with a funding status over 150% are placed in the 150% and higher band. Any plans with a funding status under 50% are placed in the 50% and lower band.
- The weights are then calculated for each band to determine what factor to apply to each band so that the funding band closely resembles the actual SE universe liabilities in that funded status band. The weights are calculated while trying to minimize:
    - The difference between weighted sample liabilities and universe liabilities within each funded band,
    - The difference between cumulative liabilities of the weighted and universe bands at lower bands, and
    - The difference between cumulative underfunding between weighted and universe bands.
- The Plan Universe data is based on a data extract of Form 5500 Schedule SB information while excluding plans that are known to have terminated or been declared probable to terminate.
- Liabilities are adjusted using common actuarial discounting techniques.

The reconciliation team reviewed the weighting analysis files that were used for FY 2021, FY 2022, and FY 2023 and validated the calculations performed.

It should be noted that the Legacy PIMS model's method of applying a weighted factor based on funded status to scale up results does introduce some limitations. In their FY 2021 peer review, Buck (Gallagher) noted that using this method could lead to inadequate coverage among different benefit types, operating status, or industries. Buck stated that this method resulted in generally sufficient and reasonable results overall but did raise the limitations discussed above that could potentially be solved with a bundling technique for small plans. Please see the Buck report for additional information: PBGC PIMS Reports and Peer Reviews.

T-PIMS Methodology

T-PIMS performs a bundling process to attempt to capture all ongoing plans in the SE Plan Universe. Contrary to the Legacy PIMS' method, this technique eliminates the need to scale up results since it models all plans within the universe. Our understanding of the process is explained through the various steps of bundling, mapping, and cash flow scaling which are discussed below.

Bundling

- All plans are extracted from a download of the Form 5500 Schedule SB. Logical exclusions occur due to duplicates, incorrect plan years, or multiple filings, for example.
- As bundling occurs, some plans are excluded from the bundling such as Tier 1 plans (the sample plans that Legacy PIMS Models), plans that indicate VRP exception, plans that terminated prior to current filing year, and plans with fewer than 100 participants with no funding target and no assets on Form 5500 SB.
- The remaining plans are considered Tier 2 plans. Tier 1 plans are modeled individually and use the data obtained from Form 5500s. Tier 2 plans with a premium funding target greater than $1 billion are modeled individually while the remaining Tier 2 plans are bundled according to plan benefit formula type (cash balance, flat dollar, salary based), plan freeze status, plan funded status, and plan sponsor industry.

Mapping

Because pertinent data is only pulled for the Tier 1 plans, these plans are used to map to the Tier 2 plans/bundles. This occurs by mapping each Tier 2 plan/bundle to a Tier 1 plan that is deemed the "closest match" based on various plan characteristics. The data that is mapped from Tier 1 plans to Tier 2 plans are active age/service census distribution profiles, participant and cash flow profiles, and actuarial assumption profiles.

Cash Flow Scaling Calculations

The Tier 1 plan cash flows are scaled so that the cash flow liability matches the total Tier 2 bundle/plan Form 5500 Schedule SB funding target liability by participant status.

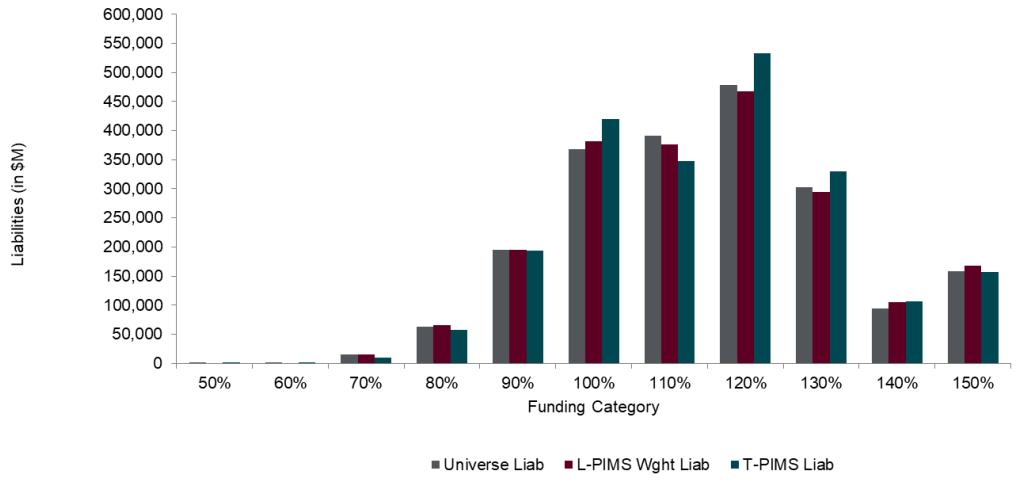
Model Results Comparison

In order to perform the review of the differences in how the Legacy PIMS and T-PIMS models represent the entire SE Plan Universe, the reconciliation team relied on data and review files performed by PRAD. For T-PIMS, we were provided a run generated for FY 2022 that showed plan level data output from the 2020 Form 5500 Schedule SB filings and reflected results of the T-PIMS bundling process. For Legacy PIMS, we were provided with a file that showed a summary of the results of the weighting factors generated for FY 2022. PBGC performed a similar review on this file and provided Plan Universe data by funding status for comparison to both models. The reconciliation team received FY 2023 results but did not include them in the analysis, but the additional information did not raise any new model reliability concerns for the team. We determined that reasonability and accuracy could be concluded from FY 2022.

Below we show an analysis that compares the Legacy PIMS and T-PIMS plan funded status distribution compared to the SE Plan Universe. As shown in the graph, both models perform well with respect to

modeling the Plan Universe. Due to fundamental differences between the models, it is expected that there will be differences in the results.

Figure 18. Comparison between Legacy PIMS and T-PIMS liabilities and the Plan Universe (FY 2022)



We also looked at another metric to assess each model's performance related to modeling the entire SE Plan Universe. Below we have compared the overall total liability modeled in Legacy PIMS and T-PIMS and provided the ratio compared to the SE Plan Universe for FY 2022.

Table 3. Comparison between Legacy PIMS and T-PIMS liability compared to the Plan Universe Liability

Description	Liability ($M)	Ratio to Universe Liability
Universe Liability	2,067,409	
Legacy PIMS Weighted Liability	2,068,698	100.06%
T-PIMS Liability	2,157,117	104.34%

While it appears the Legacy PIMS Model performs slightly better in terms of representing the Plan Universe, it is important to recognize the level of effort in calculating and creating the weights used for Legacy PIMS to scale up and the manual error it introduces as compared to T-PIMS. In addition, the bundling method performed by T-PIMS solves the limitation introduced by the Legacy PIMS Model that the weight factors do not directly factor in plan type, industry, or other factors that could be relevant to how results should be scaled.

Future Considerations

As the PRAD team updates the ME Legacy model to a ME T-PIMS model, several insights emerged that should inform both the continued development of the SE T-PIMS model as well as the ME T-PIMS model:

1. Documentation: Ensure clear documentation of the assumptions and any adjustments the plan universe calculation when comparing how well the models perform to the plan universe calculation.
2. Establish metrics: Develop metrics to routinely test the materiality of differences in plan universe composition including their impact on key program level outputs such as claims and premiums.
3. Plan universe definitions: document definitions that reflect post-SFA funding levels, participation status, and anticipated reentry into distress scenarios.
4. Model SFA behavior: Consider tracking plan exits, terminations, and SFA spending patterns explicitly to better understand tail event behavior and long-term solvency implications.

Evaluation of T-PIMS Model Reliability

From our review of the Legacy PIMS and T-PIMS SE Plan Universe models, the reconciliation team finds the T-PIMS Plan Universe representation to be reasonable and an important advancement in the model. There are clear benefits to avoiding potential biases in the scaling approach, and retaining individual plan information is a significant benefit to future modeling. The reconciliation team did find, that this change resulted in a difference of plan liabilities by approximately 5% for FY 2022. While we find the T-PIMS SE plan model reasonable and reliable for use, we believe this can be improved in future iterations of the model through further testing and calibration adjustments.

Actuarial Models Review

Introduction

The Legacy PIMS model has been used for many years to produce PBGC's annual projections report. A new model, T-PIMS, has been developed to replace the Legacy PIMS Model, with plans to fully transition beginning in FY 2025 following an additional parallel review for FY 2024 results. This section focuses on the actuarial component of both models, which generates financial projections under a range of economic and behavioral scenarios. The reconciliation team's objective was to assess whether the T-PIMS model can reasonably be relied upon for future projections by identifying and understanding material differences in output relative to the Legacy PIMS model. To support this, we examined structural model differences and assumption differences. The reconciliation team performed a field-by-field comparison of output, including root cause analysis where differences emerged, and evaluated the reasonableness of results. This section concludes with our evaluation of the T-PIMS model reliability and key considerations for future use in terms of the actuarial model.

Methodology

To better understand the drivers behind differences in projected outcomes, the reconciliation team conducted a detailed field-by-field review of the two models for FY 2022 and FY 2023. For each key field, we analyzed year-over-year projections and compared results at various probabilistic points, specifically the 1st, 15th, 50th (Median), 85th, 99th percentiles as well as the mean. This allowed us to assess not only the central tendencies of each model but also the dispersion and range of potential outcomes. Where possible, we brought in historical data to contextualize projections – evaluating whether the magnitude of projected changes and their variability aligned with historical experience and standard deviation patterns over time. We also reviewed the run build-ups provided for each model and conducted a cross-walk analysis to isolate whether observed differences were attributable to actuarial programming, de-risking, or the bankruptcy model used.

While this report does not detail every element of this internal analysis for each field, this work was conducted comprehensively and supports the key findings highlighted. It is also important to emphasize that, because these models are stochastic, results represent distributions of possible outcomes, not deterministic predictions. When interpreting the projections, particularly the mean and percentile values, it is critical to recognize that differences between models may reflect differences in assumptions or model structure, and that variability in outcomes is an expected and meaningful part of stochastic analysis. In short, we focus on identifying material differences, while also acknowledging that a range of results is inherent to this type of modeling.

In our analysis, the reconciliation team considered the calibration of the models at the mean, 50th percentile, and the extreme 1st and 99th percentiles. Model calibration refers to the setting and adjusting of a model's inputs, parameters, assumptions, and relationships between variables so that its outputs align with observed historical or known behaviors. It is by testing the results of the model that we can validate the calibration and that we ensure a model is realistic and grounded in historical experience. Considering the extreme scenarios tests the behavior of the models not just in average conditions, but also in extreme scenarios.

The reconciliation team assessed the extreme behavior of different variables throughout the analysis, even though they represent extreme and rare events, because they represent possible and impactful outcomes. These scenarios might include large changes in market returns, sharp interest rate movements, or large numbers of bankruptcies. Even though these events are not expected to happen often, they are critical to correctly model and understand because they test the limits of the PBGC's SE program's resilience and financial strength. They help identify vulnerabilities that may not show up in projections of mean values, and present scenarios of what could happen in extreme circumstances. The full dispersion of results – from the mean to the least likely scenarios gives a more complete understanding of the risk profile of the SE program and can support decision-makers in planning for a full range of potential outcomes – not just the most likely ones.

The overall findings from the reconciliation review of the Legacy PIMS and T-PIMS actuarial models are that the T-PIMS model appears to be reasonable and reliable for its intended purpose. As discussed below, there are fields which could benefit from improved calibration of mean or variance, but the model appears to be sound with generally improved fitting of extreme values compared to the Legacy PIMS Model.

Comparison of Structural Differences

In addition to differences in how certain calculations are modeled, the results are influenced by variations in each model's bankruptcy projection framework, economic scenario generator output, and the way each model represents the underlying single-employer Plan Universe. These differences can lead to notable variation in the mean values, and in some cases, the divergence may appear significant. In many cases, observed variations were consistent with the expected behavior of the T-PIMS model based on its design enhancements.

At this time, there is no comprehensive documentation that compares the differences in how each individual calculation or projection is handled. As such, and consistent with our scope, the reconciliation team did not review the technical specifications or programming logic for each field. Instead, our review focuses on comparing the output of the two models, identifying where material differences exist, and assessing whether those differences are reasonable given known structural and assumption-based variations.

In addition, T-PIMS introduces fundamental differences in model infrastructure. As a newly built, cloud-based model, T-PIMS is designed to be more flexible, easier to maintain, and more user friendly. This design shift improves long-term maintainability, increases transparency, and supports more efficient updates in the future.

Alignment on Data Input and Assumptions

For this review, the reconciliation team was provided with summarized raw output data from both the Legacy PIMS and T-PIMS models. These data sets included key percentile metrics (1st, 15th, 50th, 85th, 99th, mean) for each of the key fields over the projection period. We were given the final projection runs used to generate the projection results for each Fiscal Year, as well as a series of additional runs that were designed to isolate the impact of specific modeling features such as de-risking and bankruptcy model impacts and they were essential in helping us discern the effects of structural differences in actuarial modeling. We also received sample run data and plan level output files for a subset of plans

which helped us validate our findings and offered additional context where needed. Our analysis relied on the accuracy of the summary data provided.

In addition to the data output provided, PRAD also provided the reconciliation team with model documentation for each model that explained some of the structure and mechanics of each model. These materials were especially important for understanding the logic behind model changes, the intent of new T-PIMS modeling, and how assumptions were applied in both models. We understand that the assumptions and inputs used in both the Legacy PIMS and T-PIMS models run for FY 2022 and FY 2023 were consistent with those used for the projections reports; however, the economic scenarios used for Legacy PIMS were changed to what was used for T-PIMS.

Model Results Comparison

We assessed the materiality of the identified differences in results and determined whether they are reasonable and expected based on model changes or if they indicate potential errors of the model. Our findings are discussed throughout the remainder of the report. In the table below, we summarize the PBGC Nominal Net Position projection results at the end of FY 2033.

Table 4. Variability in FY 2033 PBGC SE Nominal Net Financial Position ($B) based on FY 2023 results

PBGC Nominal Net Position	Legacy PIMS	T-PIMS	% Variation
Mean	$97.1	$112.4	15.7%
1st Percentile	$64.1	$47.3	-26.1%
15th Percentile	$85.3	$99.2	16.3%
50th Percentile	$97.6	$112.8	15.6%
85th Percentile	$108.9	$128.7	18.2%
99th Percentile	$122.8	$152.6	24.3%

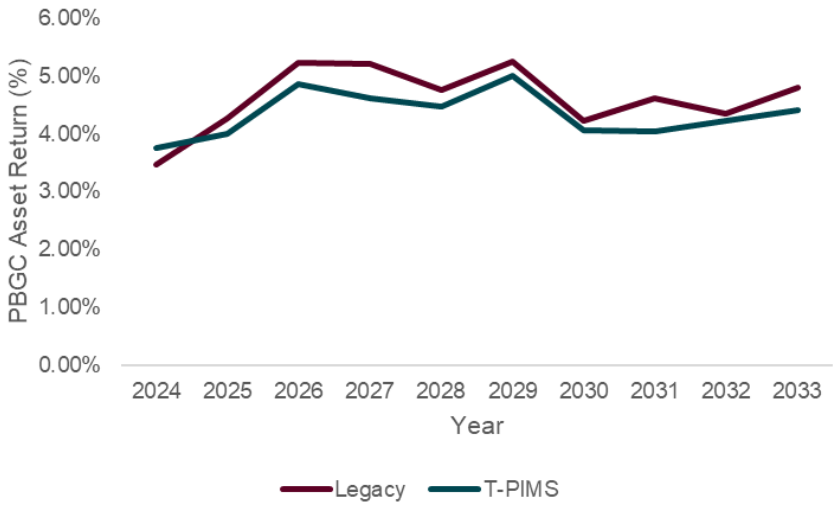
The FY 2023 Reconciliation and FY 2022 Reconciliation Tables in the Appendix summarize key 10-year projection results from both models. For each field, we display the mean outcome at the end of the projection period across the stochastic simulations performed by each model. While these summary values offer a high-level comparison of the model outputs, it is important to note that the two models have fundamental differences in their structure, assumptions, and specifications. Below we summarize our findings from our analysis of our field-by-field review of the actuarial model outputs.

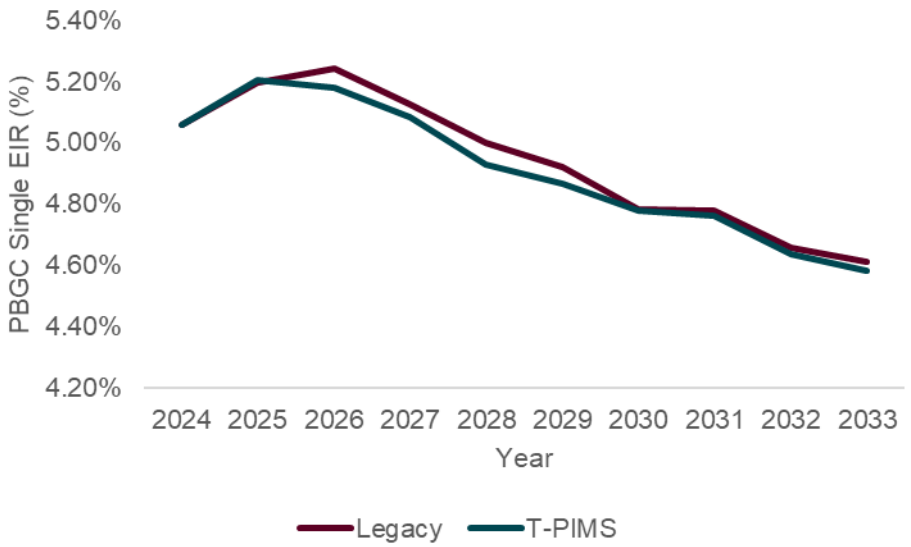
Impact of Benefit Payment Assumption Update

Following the delivery of our interim report, PRAD identified a key difference between the T-PIMS and Legacy models related to how benefit payments were modeled. Specifically, the T-PIMS model for FY 2023 did not initially account for lump sum distributions in cash balance plans. This discrepancy introduced noise into several output fields and was addressed in a subsequent run to better align the assumptions. The updated results underscore the significant influence a single modeling assumption can have on key projections. However, it's important to note that this situation reflects a transitional modeling approach. The T-PIMS model is designed to use 50-year benefit payment streams from Form 5500 filings, which first become available in 2022 Form 5500 filings. Because FY 2022 and FY 2023

projections would use the Form 5500 data from years 2020 and 2021 respectively, these benefit payment streams were not yet available to use in the T-PIMS model. During this evaluation the T-PIMS model relied on Legacy derived inputs.

While we did not revise the results or conclusions presented in our interim report, we have added *italicized commentary* throughout our analysis to reflect observations based on the updated model run. This commentary was only included in fields where the assumption change led to noticeable differences. Additionally, we have provided a supplemental appendix table summarizing the updated results to allow for easy comparison alongside the original outputs. These additions are intended to enhance transparency and highlight how specific modeling choices, such as the treatment of benefit payments, can influence key projections without altering our overall assessment of model reliability.

Bankruptcy Model and Economic Conditions	
PBGC SE Program Investment Returns	
Materiality	Low
Reasonableness	The T-PIMS model reasonably projects the SE Program Investment Returns
Commentary	The projected values of the SE Program Investment Returns between the Legacy PIMS and T-PIMS models are distinct but follow very similar trends. The fact that both models show reasonable alignment in their changes over time is an indicator of the overall validity of both models. They likely use similar approaches to forecasting asset returns and as time progresses, it is expected that both models will follow similar paths. We expect that both models are effectively capturing the long-term dynamics of asset returns and considering market dynamics such as volatility, correlation with economic factors, and mean reversion. Figure 19. Projected PBGC Asset Returns for Legacy PIMS and T-PIMS Models (FY 2023) 
FY 2022 Commentary	For FY 2022, the first-year projected rates were 3.43% and 5.55% for Legacy PIMS and T-PIMS, respectively. Although the first-year projected amounts were different, the rates between models over time realigned and are reasonable, supporting the models' tendency to revert to mean assumptions. The fact that both models show reasonable alignment in their changes over time in both years is an indicator of the overall validity of both models. Even though the modeling appears reasonable, consideration may be given to better matching starting values.
Single Equivalent Liability Interest Rate	
Materiality	Low
Reasonableness	T-PIMS Model has reasonable results
Commentary	The results for the Single Equivalent Liability Interest Rate (EIR) from the Legacy PIMS and T-PIMS model are not materially different, and the T-PIMS results fall within 5% of the

	Legacy results in every projection year. Both models appear to be appropriately calibrated to project interest rates that align with economic conditions and historical trends. Interest rates often have lower volatility than asset returns, especially when considered over a longer projection period. Considering both models rely on the same economic factors, it is expected that they have similar results for variables such as interest rates. Figure 20. Projected Single EIR for Legacy PIMS and T-PIMS Models (FY 2023) 
FY 2022 Commentary	The single EIR used for both models for FY 2022 was almost identical for the projections, even at the low and high percentiles. Above we demonstrate the consistency in results for the T-PIMS model across Fiscal Years and the differences for the Legacy results.
SE Plan Assets and Investment Returns	
Materiality	Medium
Reasonableness	T-PIMS model projections are within a reasonable range but are low compared to what is expected. Further testing is recommended to fix complications related to known bugs in the prediction of investment returns.
Commentary	Both the Legacy PIMS and the T-PIMS models exhibit a close fit to recent historical data. This is a strong positive indicator of their reliability. The calibration process has been successful in capturing the expected behavior of the SE Plan Investment Returns over the next 10 years. While the Legacy PIMS Model has reasonable results, it likely has a simpler structure or is missing nuanced parameters which may limit its ability to capture more complex interactions in the Investment Returns over time. The T-PIMS model has greater dispersion in the tail of the distribution. This means it is projecting more extreme market scenarios, both positive and negative, compared to the Legacy PIMS Model. Greater tail dispersion in the plan asset values could indicate that the T-PIMS model is better at anticipating rare but impactful and possible events, providing a more realistic understanding of potential extreme market conditions over time. The T-PIMS model tail dispersion is closer to the historical standard deviation multiplied by the square root of 10 (reflecting 10 time steps) and adjusted by the

	appropriate z-value. This indicates more accurate modeling of the risk over the projection period. This approach appears to leverage stochastic methods to project how volatility accumulates over multiple time periods in a time series projection model and represents how financial risks evolve over time. Based on the standard deviation of the last 10 years, we expect a 99th percentile after 10 time steps for plan assets to be approximately mean + $2100 B. At the end of the projection period, the Legacy PIMS Model has a 99th percentile of mean + $800 B and the T-PIMS model has a 99th percentile of mean + $1400 B. There is a potential risk that the Legacy PIMS Model is underestimating the risk of tail volatility over the 10-year projection period and therefore may not be fully compounding the nature of dynamic market values over time. While there are many inputs to the plan assets that can affect the dispersion of the models over time such as the benefit payments or derisking activities, we find that the tail behavior of the T-PIMS model appears to be an improvement over the Legacy model. While both models show slight right skewed distribution of plan assets with means in excess of the 50th percentile in the final projection year, the Legacy PIMS Model has less right skewness. This could indicate a more conservative risk profile that limits its ability to capture the full potential of market growth, especially in scenarios where the market experiences a strong upward trend for multiple years in a row. In particular, the recent market value of assets of $2,858B in 2021 is outside the 99th percentile of any year in the next 10 years for the Legacy PIMS Model. The T-PIMS model performs better with accounting for unexpected historical results. In the T-PIMS model, the 2021 return is within the 99th percentile for the projection period. It should be noted that there is some expectation that future results may not align directly with historical results given pension data trends but even with this context it is clear the T-PIMS model performs better at modeling for unexpected future events. We also noted that the T-PIMS median projection asset return is lower over time (4.5% on average vs 5.5% in the Legacy PIMS Model). After discussions with PRAD, we note that the T-PIMS model appears to be using a 0% rate of return for terminated plans in their summary statistics, which is a known issue waiting to be resolved in the model. Once this issue is resolved, we recommend further careful testing to be sure the results are well fit to historical experience and asset returns generated by the ESG. The Legacy PIMS Model is reasonable, reliable, and likely more stable than T-PIMS. However, it may underestimate the potential for tail risks or extreme events. The T-PIMS model appears to provide a more robust, flexible, and accurate representation of actual market value assets and returns while capturing more realistic tail risk. It better handles the skewed distribution of investment returns and incorporates higher volatility into the projection period. The difference in means of the Legacy PIMS and T-PIMS distributions should not be of major concern as the means are significantly affected by the tail results and a higher starting value as well as different approaches to projecting benefit payments. The larger variance in the T-PIMS model causes the difference between models to increase over the time steps of the projection period. For decision-making that requires sensitivity to rare events and higher volatility, the T-PIMS model is likely an improvement over the Legacy PIMS Model. *The revised T-PIMS run incorporating the updated benefit payment methodology had a direct impact on projected plan market value of assets. Previously, the final projection year mean for T-PIMS differed from the Legacy model by approximately 40%. The update narrowed that difference to about 20%. While this adjustment materially improves alignment between the two models, it does not alter the overall trends, tail behavior, or directional*

patterns observed over time. The consistency in shape and behavior of the projections suggests that the update addressed a structural difference without impacting the fundamental modeling approach for asset growth and depletion.

Below we show how each model projects the plan market value of assets over the next 10 years along with historical information back to 2014 as reported in the Form 5500 Schedule SB (Line 2a).

Figure 21. Historical and Projected Plan Market Value of Assets for Legacy PIMS Model (FY 2023)

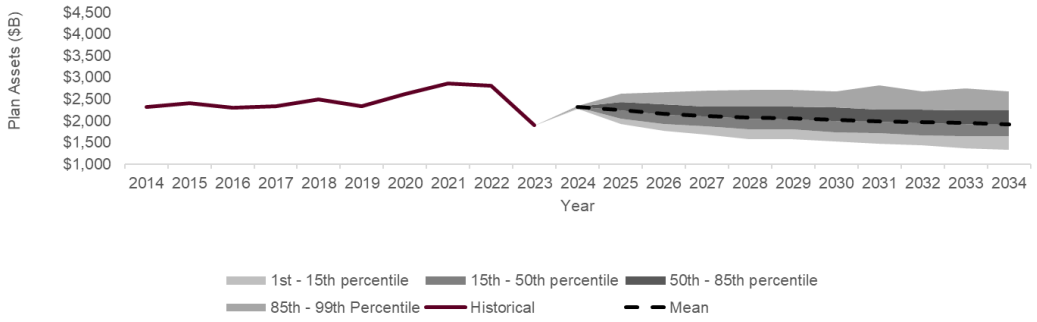
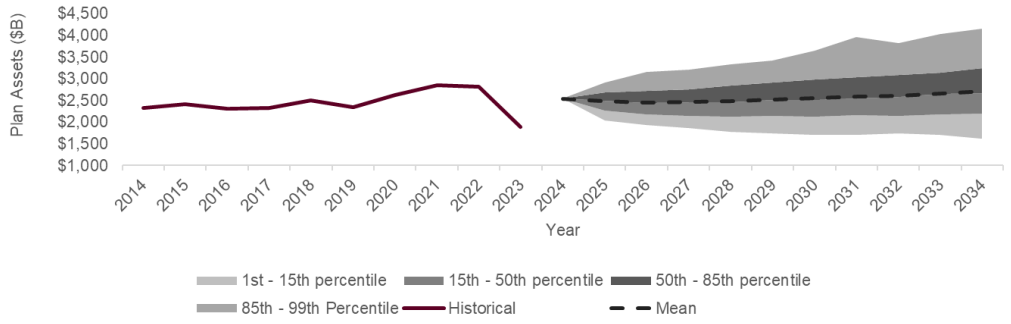


Figure 22. Historical and Projected Plan Market Value of Assets for T-PIMS Model (FY 2023)



FY 2022 Commentary

Similar to FY 2023 results, both the Legacy PIMS and the T-PIMS models exhibit a close fit to recent historical data. This is a strong positive indicator of their reliability. The calibration process has been successful in capturing the expected behavior of the SE Plan Investment Returns over the next 10 years.

SE Plan Bankruptcy Rate	
Materiality	High
Reasonableness	The T-PIMS model may be overstating Bankruptcy Risk, particularly for certain classes of credit ratings
Commentary	The difference in the mean rates of bankruptcy between the Legacy PIMS and T-PIMS models - 0.5% vs 1% - is an important difference between the two models. As discussed above in the bankruptcy model review section, T-PIMS assumes a higher risk of bankruptcy for some groups. We also noted that bankruptcy in the T-PIMS model has significantly greater tail dispersion. T-PIMS adequately captures a wider distribution of default possibilities compared to Legacy PIMS, but it may be generating a more conservative financial outlook for PBGC at the extreme values of the tail. A higher than historical rate of bankruptcy could result in a more conservative approach to planning with excess capital projected to be needed to protect against the perceived higher risk of ruin. It could also result in unnecessary precautionary measures taken over time. To address the potential overstatement of bankruptcy risk in the T-PIMS model, it may be useful to try the following approaches: • Calibrate the tail behavior carefully, matching historical data or adjusting parameters for extreme events to reflect historical incidence of extreme events • Test the sensitivity of the model by varying key parameters to ensure the results are not unduly influenced by rare events • Conduct scenario testing to determine the likelihood of projected tail events in real-world scenarios It may be worth revisiting the tail behavior of the bankruptcy risk to better align to recent historical experience, but if the goal is to be more conservative and capture more extreme event behavior, this aspect of the T-PIMS model may be seen as a strength compared to the Legacy PIMS Model.
FY 2022 Commentary	While there are differing starting points, there are no material differences between FY 2022 and FY 2023 for the T-PIMS model. As we note above in our discussion of the bankruptcy models, the movement in bankruptcy rates between fiscal years is consistent with what is expected based on the changes in the ESG.
SE Plan Fields	
SE Plan Participant Counts	
Materiality	High
Reasonableness	Results are reasonable compared to both historical values and the Legacy PIMS Model results
Commentary	Below we summarize our analysis that compared the total participant counts projected between both models. We performed this analysis for each participant status (active, retiree, and terminated vested), but show the total population to demonstrate our findings. While the T-PIMS model results in higher participant counts than the Legacy PIMS model, they are both aligned closely to recent historical values and trends. The main driver of differences between the outputs can be attributed to the general difference in model

specifications for how they model the SE Plan Universe. T-PIMS uses a bundling technique while Legacy PIMS scales up from a sample of plans based on the distribution of plan funded statuses. The T-PIMS approach results in an initial value closer to the historical values, and likely will be more aligned with actual changes over time. Both models exhibit alignment on trends over time across percentiles demonstrating that most of the difference between models can be attributed to their starting values. Even though the starting values differ between the models, the trends over time align well with each other and with historical experience. This suggests that they both effectively model the evolution of participant counts over time.

On average, we noted that the starting active counts were low compared to historical amounts for Legacy PIMS, and terminated vested counts were high for the T-PIMS starting projection. Both models appeared to overestimate the starting retiree counts. The T-PIMS model has higher than expected (and higher than Legacy PIMS) retiree counts, which raises concerns. We raised this issue with PRAD to understand how annuity purchases and lump sums are modeled in T-PIMS. PRAD demonstrated how annuity purchases are modeled, which we found to be reasonable.

Relying on actual participant counts across the full universe of plans is a significant advantage for the T-PIMS model. It removes the potential for modeling error related to the scaling approach that Legacy PIMS implemented. Scaling approaches can sometimes introduce bias or error to a model's results that are removed by direct modeling.

The updated T-PIMS run resulted in a modest shift in total participant counts, driven by the incorporation of lump sum payments for cash balance plans. This reduced the overall participant count in T-PIMS, bringing it closer to the Legacy model's values, though a difference still remains. Importantly, this adjustment did not alter the projected patterns or trends over time, which remained consistent.

Below we show how both models project the total number of participants over the projection period and how those trend against historical data found in the PBGC Data Tables (specifically table S-30).

Figure 23. Historical and Projected Total Plan Participants for Legacy PIMS Model (FY 2023)

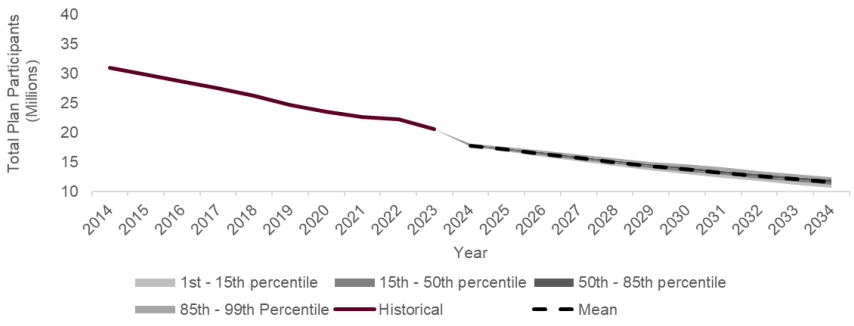
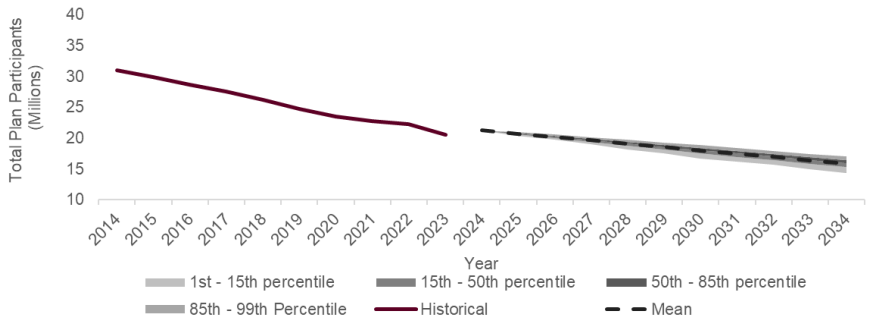


	Figure 24. Historical and Projected Total Plan Participants for T-PIMS Model (FY 2023) 
FY 2022 Commentary	While starting values are slightly different, there are no material changes in total participants between the FY 2022 and FY 2023 model projections.
SE Plan Target Normal Cost and Funding Target	
Materiality	High
Reasonableness	<u>Target Normal Cost</u> Target Normal Cost in the T-PIMS model is almost twice that of the Legacy PIMS Model. We investigated these differences to determine their root causes. Known root causes, comparisons to historical amounts, and a wider dispersion of results lead us to determine that T-PIMS is reasonably projecting Target Normal Costs, but the reconciliation team has additional recommendations to consider to further validate the T-PIMS model. <u>Funding Target</u> Funding Target has a similar starting value between the two models, but has different trends, meaning the ending value for T-PIMS is higher than Legacy PIMS by 30%. The similar starting points support the reasonableness of the T-PIMS model. We investigated the divergent trends to ensure the reliability of the T-PIMS model going forward.
Commentary	<u>Target Normal Cost</u> For FY 2023, the Legacy PIMS Model projects a mean value of $34B in Target Normal Costs (TNC) at the end of the 10-year projection period while T-PIMS projects $68B. TNC in the T-PIMS model is approximately 100% higher than the Legacy PIMS Model at the mean and is accelerating up at the end of the projection period and across higher percentiles. The Legacy PIMS Model has relatively level TNC projections throughout the period. The actuarial programming of the T-PIMS model is the driver of the TNC differences. In T-PIMS, due to the bundling process, TNC is directly determined by plan instead of being scaled, and its first-year projection, $47.7B, is closer to the historical value of $49B (2022 Form 5500 Schedule SB) than the Legacy PIMS value of $32.7B. Additionally, the T-PIMS model has been improved by adding in plan expenses to the TNC. The inclusion of administrative expenses has a substantial impact. When asked the impact, PBGC made note that “the total admin expense out of total TNC ranges from ~15% in the

initial years up to ~25% toward the end of the projection period". Additionally, the projected increases in expenses due to inflation and an increase in the value of TNC due to decreasing interest rates in future years explain much of the acceleration of differences between the T-PIMS model and the Legacy PIMS Model. When compared to historical values, the T-PIMS model appears to be more closely aligned. The difference in both starting value and trend over time between the Legacy PIMS Model and the T-PIMS model should not be dismissed as invalid. The actuarial programming and building up of the TNC is different between the models, and results in a different TNC trend over time. Additionally, T-PIMS currently may not be reflecting salary growth in normal costs, which will drive T-PIMS results further up and away from both the historical values and the Legacy PIMS results. The reconciliation team was provided additional runs that included future updates to the T-PIMS model which reportedly resolve this issue. Our team did not incorporate these updates in our review and we recommend PRAD test these results to verify that they are incorporating salary growth as intended. Below we have shown a comparison between the models and their dispersion of results showing the wider tail projected by the T-PIMS model.

Following the benefit payment assumption update in T-PIMS, the projected Target Normal Cost values diverged further from those produced by the Legacy model. While the general pattern of Target Normal Costs over time remains consistent between models, the updated results underscore the importance of continued review and testing by PRAD.

Figure 25. Historical and Projected Target Normal Costs for Legacy PIMS Model (FY 2023)

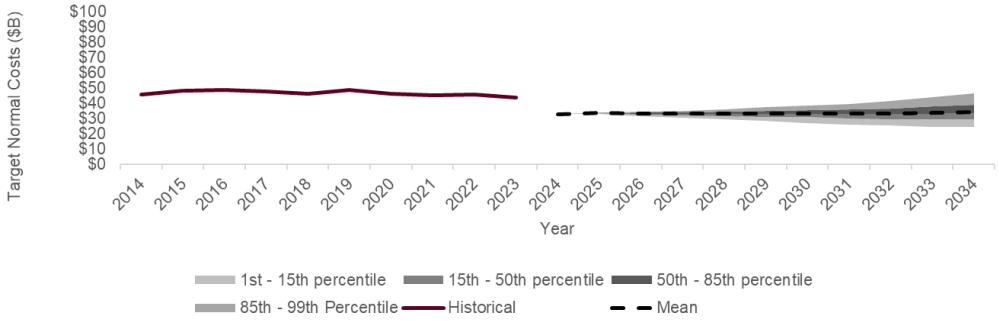
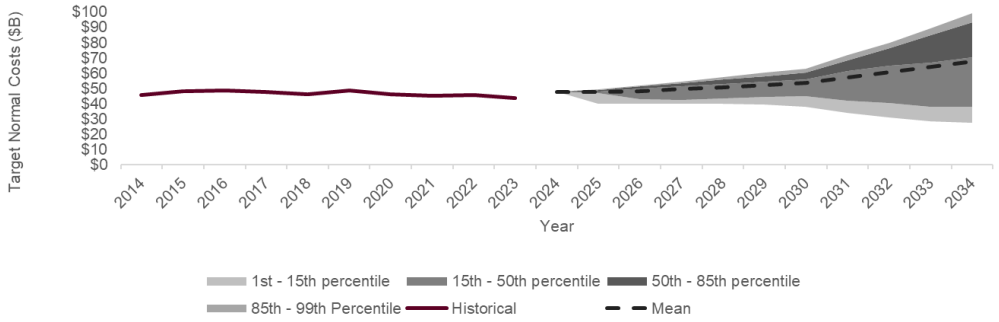


Figure 26. Historical and Projected Target Normal Costs for T-PIMS Model (FY 2023)



Funding Target

The Funding Target projections for both Legacy PIMS and T-PIMS start within 5% of one another, but Legacy PIMS has a steeper negative trend over the projection period, so the ending values are different by 30%. Notably, the starting values for both the Legacy PIMS and the T-PIMS model are above the 2023 historical value, which was unexpectedly lower than the historical mean. The 2023 historical value is out of range of the confidence interval for many time steps for both models, influenced heavily by the unusually rapidly shifting interest rate environment. It is recommended that the historical value and the starting projection point for both models are studied further to ensure that the starting point is appropriate.

While both models start at a similar point, there is an increasing difference in the mean values as the projection period moves into the future. We identified the root cause of the model differences as the modeling of benefit payments in the T-PIMS model. This difference increases the distance between the mean values of the two models with each time step. The standard deviation of the historical data from years 2014 – 2022 is $65B, so after 10 time steps into the future, we would expect a standard deviation of approximately $205B, or a 99th percentile of approximately mean + $480B. The 99th percentile of the LPIMS model is mean + $261B, while the T-PIMS model 99th percentile is mean + $580B. The T-PIMS model projects dispersion more similarly to what is expected. Note that we excluded the most recent year from our estimate of the standard deviation of the historical data as we expect this is a one time shift due to external forces instead of natural variation in amounts.

The updated benefit payment assumption in T-PIMS resulted in a material reduction in the projected Funding Target values for the T-PIMS model. Previously, the final projection year mean for T-PIMS differed from the Legacy model by approximately 30%. The update narrowed that difference to about 10%. The update brought T-PIMS projections much closer to those produced by the Legacy model, significantly narrowing the gap that had existed. The adjustment improved alignment on this key liability measure and supports the reasonableness of the T-PIMS liability projection framework. Importantly, the general shape and pattern of the Funding Target projections over time remain consistent.

Figure 27. Historical and Projected Funding Target for Legacy PIMS Model (FY 2023)

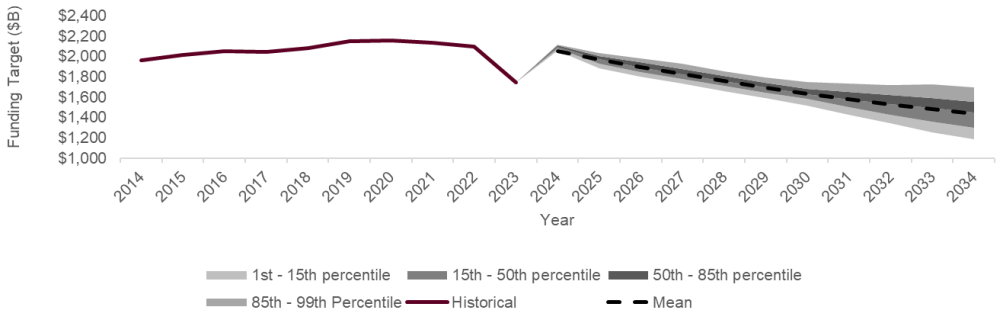
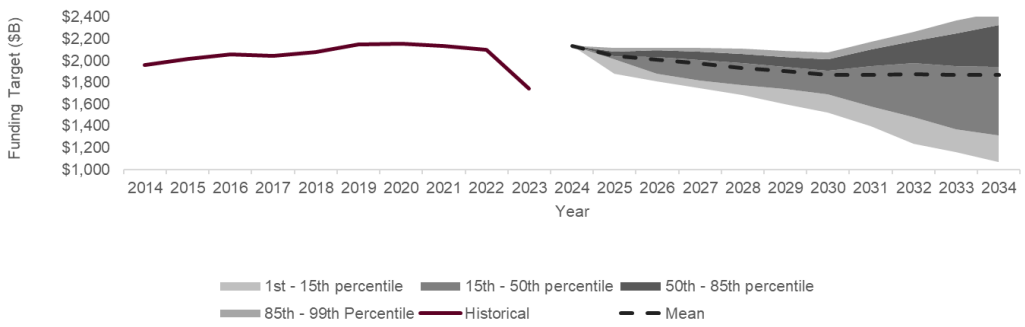


	Figure 28. Historical and Projected Funding Target for T-PIMS Model (FY 2023) 
FY 2022 Commentary	Target Normal Costs While there are different starting values between the years, there are no material differences in the models between years. Funding Target The Funding Target projections for both Legacy and T-PIMS start within 5% of one another in the FY 2022 projection as well as the FY 2023 projection, but Legacy again has a steeper negative trend over the projection period, so the ending values are different by 13% for FY 2022. While both models start at a similar point, there is an increasing difference in the mean values as the projection period moves into the future driven by the modeling which has significantly larger dispersion in the tail for the T-PIMS model. This trend and relationships are present in the FY 2022 results as well but not as amplified as in FY 2023. We expect that this is because the benefit payment models were more closely aligned in FY 2022.
SE Plan Benefit Payments and Expenses	
Materiality	Medium
Reasonableness	Benefit Payments Benefit payments in T-PIMS model for 2023 have a flat trend, different than the negative retiree participant count trend. The mean value at the end of the projection period is within 5% of the Legacy PIMS value, but the intervening time periods have different trends and starting values. Additionally, the dispersion of the tail is wider in the T-PIMS model than the Legacy PIMS Model. The benefit payments and expenses are more reasonable, particularly at the end of the projection period. Expenses Expenses in the T-PIMS model for FY 2023 have a higher starting value but a similar trend to the Legacy PIMS Model. As documented in the above section, T-PIMS does value more liability than the Plan Universe as measured for FY 2022 which may cause the expenses to start a slightly elevated amount.
Commentary	Benefit Payments Benefit payments in the Legacy PIMS Model trend down over time throughout the projection period, similar to the participant counts. The Legacy PIMS Model derives plan benefit

payments from an assumed census, benefit provisions, and decrements that are loaded in for the sample plans and used for scaling results. The T-PIMS model is designed to use 50-year benefit payment streams from Form 5500 filings, which first became available in 2022. Because FY 2022 and FY 2023 projections would use the Form 5500 data from years 2022 and 2021 respectively, these benefit payment streams were not yet available to use in the T-PIMS model. Instead, PRAD used projections from the Legacy model to fill in this gap and used as inputs for the T-PIMS model until the Form 5500 data will be available. Initially, PRAD brought in all benefit payment projections from the Legacy system as single life annuities, regardless of plan designs or assumptions. This is leading to a significant difference in projected benefit payment streams as the Legacy model projected lump sums to be paid by cash balance plans.

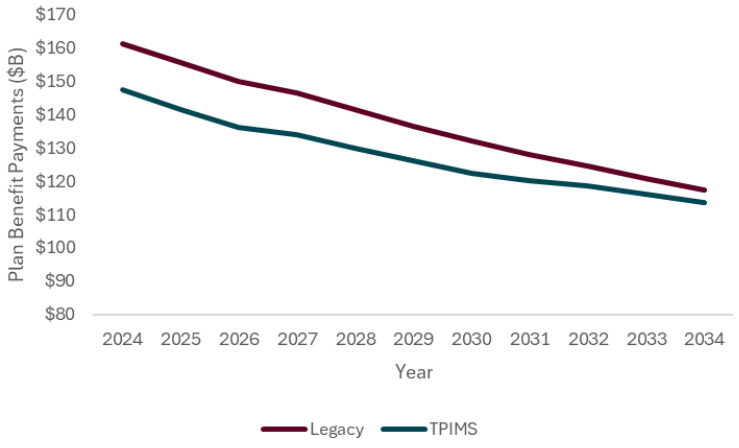
The vital testing that needs to be done is testing the difference in results between the Legacy PIMS model projecting benefit payment streams and the T-PIMS model using Form 5500 data when the 2022 Form 5500 data becomes available and the 2024 projections are run. PRAD should prioritize this testing to ensure it is operating as intended as we have noted that differences in the projection of benefit payments have a significant impact on the results of the model overall.

The T-PIMS model initially had level benefit payments throughout the projection period due to the simplification of inputting only single life annuities for all participants instead of including lump sums. The differences in benefit payments can be attributed to two main differences:

1. How each model represents the Plan Universe will lead to differences in starting points. The Legacy PIMS Model scales up to the Plan Universe from the sample whereas T-PIMS uses Tier 2 bundles which are mapped to cash flow patterns of their associated Tier 1 closest match as outlined in an earlier section.
2, The Legacy PIMS Model assumes cash balance plans pay out lump sums while the T-PIMS model assumes cash balance plans pay out all annuities.

After highlighting the differences in benefit payments between models, PRAD was able to verify that much of the difference can be attributed to #2 above and by changing the assumed form of payment the two model outputs aligned closer in terms of benefit payments.

Figure 29. Projected Plan Benefits for Legacy PIMS and T-PIMS Models (FY 2023)



Expenses

Both the Legacy PIMS and T-PIMS model have relatively level plan expenses on average throughout the projection period. The T-PIMS projection starts higher at $7.3B versus $6.6B for Legacy PIMS. While this accounts for a starting 10% difference, it should be noted on a materiality basis that it has a relatively low impact on the overall model results. Expenses at the end of the projection period are still less than 10% of the benefit payments. Some of the differences can be attributed to the general difference in the way the models represent the Plan Universe. We note that T-PIMS may be slightly overestimating the overall plan liability in the SE Plan Universe which could lead to differences in the number of plan expenses. This is demonstrated further by the estimated participant counts discussed above which directly correlate to higher plan expenses in T-PIMS due to higher estimated number of participants. On average both models exhibit a downward trend over the projection period. Additionally, the T-PIMS model does have a wider dispersion of results to account for unforeseen circumstances. It takes into account a wider range of potential events such as a wider dispersion in participant count projections.

The updated benefit payment assumption had a minimal impact on projected Plan Expenses. While values increased slightly in the revised T-PIMS run, the overall magnitude of the change was small and did not affect the general pattern or trend observed over time.

Figure 30. Projected Plan Expenses for Legacy PIMS Model (FY 2023)

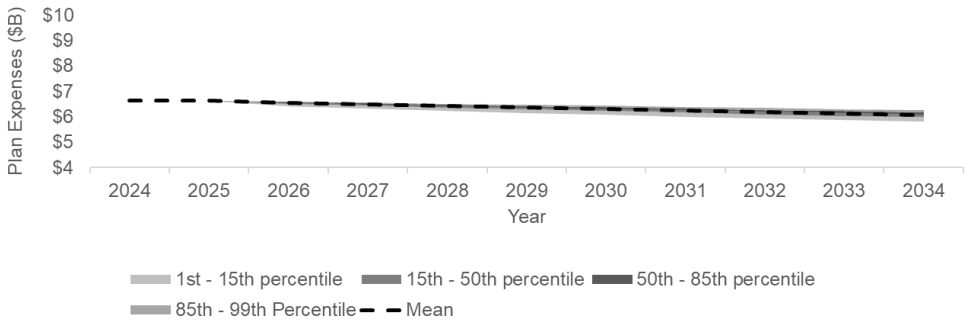
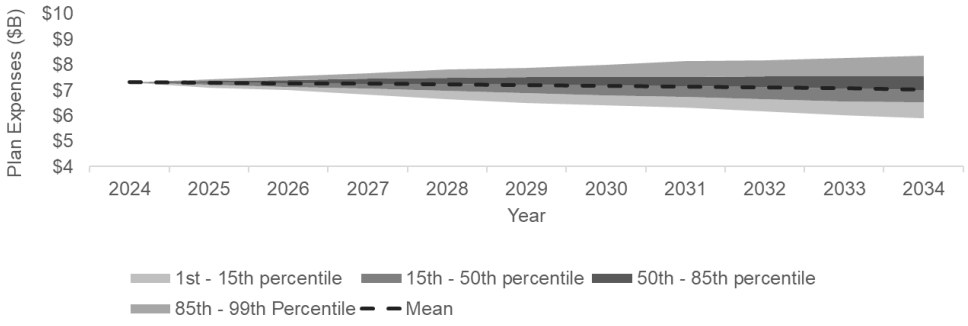
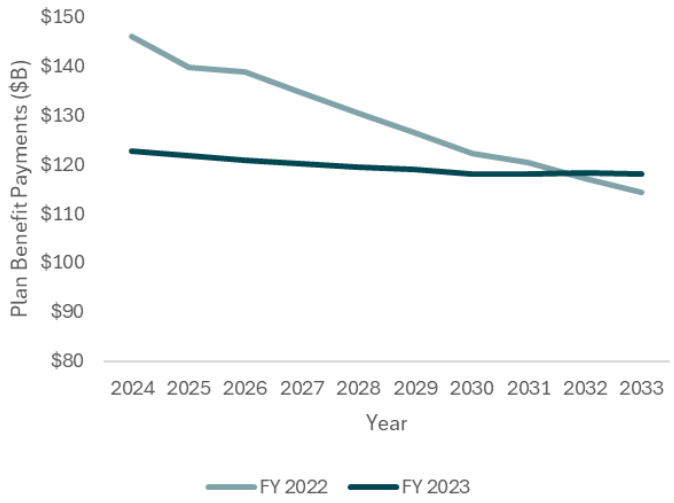


Figure 31. Projected Plan Expenses for T-PIMS Model (FY 2023)



FY 2022 Commentary	Benefit Payments For the 2022 projection year, there are no benefit payments available to review for the Legacy PIMS Model. The trend of benefit payments in the T-PIMS model trend down over time throughout the projection period, similar to the participant counts. This is a significant difference to the FY 2023 results and should be studied further by PRAD. For purposes of our review, we note the trend difference but acknowledge that the T-PIMS projections between fiscal years have similar final averages. Figure 32. Projected Plan Benefits for T-PIMS Models for FY 2022 and FY 2023  Expenses For the FY 2022 projection year, there are no plan expenses available to review for the Legacy PIMS Model. The trend of expenses is similar to the trend of benefit payments in the T-PIMS model over the projection period. However, the plan benefit payments starting points between fiscal years is significant. For FY 2022 the average plan expenses over the projection period are $11.57B versus $7.19B for FY 2023. Upon discussions with PRAD, it was determined that the large difference in expenses in the FY 2022 plan year appears to be caused by input data in that year being incorrectly filtered. Recent actual data from the Form 5500 Schedule SB supports this conclusion and supports a starting value for FY 2023 of $7.19B. Given this finding and difference PRAD should consider further testing and validation of the starting plan expenses amount from Form 5500 Schedule SBs.
SE Plan Minimum Contributions and any Assumed Excess Contributions	
Materiality	Medium
Reasonableness	T-PIMS and Legacy PIMS Minimum and Assumed Excess Contributions are reasonable given other variables

Commentary	Minimum Required Contributions As part of our review, we evaluated the minimum required contributions (MRCs) projected by each model. MRCs are determined by statute, specifically under the rules set forth in the Employee Retirement Income Security Act (ERISA), as amended by the Pension Protection Act of 2006 (PPA) and subsequent legislation. Because these rules define a standardized methodology for calculating MRCs, both models are designed to follow the same statutory framework. As a result, the large differences observed in MRC projections are not due to how the calculation is performed but rather due to differences in the input data or assumptions that feed into the statutory formula. Assumptions include the target normal cost and unfunded liability amortization. We reviewed the MRC output in relation to key inputs, and the magnitude of the projected contributions appeared reasonable given our review of inputs such as the target normal costs. Assumed Excess Contributions We also reviewed the assumed excess contributions projected by the plans which are modeled based on plan sponsor behavior. Our understanding is that both models are aligned with their assumption approach and follow the PRAD PIMS Contribution Policy memo from February 2021. Therefore, any differences in projected assumed contributions are likewise attributable to differences in other variables rather than differences in how the assumption itself is applied in the model. We reviewed the output generated by each model and found that the direction of the results was consistent with expectations based on the assumptions laid out in the PBGC memo.
FY 2022 Commentary	There are no material differences in the FY 2022 results for the minimum required contributions or the assumed excess contributions compared to the FY 2023 results which are discussed above. We determined that the root cause of the large differences observed in the projections are not due to how the calculations are performed but rather due to differences in the input data or assumptions that feed into the statutory formula and the assumptions in the PRAD PIMS Contribution Policy memo from February 2021.
SE Plan Premiums	
Materiality	High
Reasonableness	The T-PIMS model flat rate premiums calculations are reasonable. However, PRAD should further test future implied flat rate premium rates after updates are made to the ESG model regarding including inflation in the wage assumption. Variable Rate Premiums may need further calibration or support but appear reasonable in the long term.
Commentary	Flat Rate Premiums Flat Rate Premiums for SE pension plans are set by Congress and are directly correlated to the total participants. For FY 2023, the flat rate premium was $96/participant. We would expect the Flat Rate Premiums to be calculated the same between models but results will differ due to other variable changes such as participant count, which is also affected by bankruptcies and claims, etc. As expected, we found that the models had different starting points for the flat rate premiums, related to the different participant counts. The models appeared reasonable in their projection of the flat rate premiums based on these participant counts. It should be noted that premium scaling does take place to offset the difference in flat rate premium caused by participant count differences in the T-PIMS model.

Using total participant counts projected in both models, we calculated the future implied flat rate premium rates for each model and note a lower than expected flat rate premium rate per participant. On average we saw an average increase of 1.28% for T-PIMS over the projection period in the implied flat rate premium rate and 4.12% for Legacy PIMS. These rates compare to a historical average over the last 10 years of 7.84%. While there have been elevated levels of inflation over the last few years, the T-PIMS rate does seem to be quite low compared to historical experience. PRAD noted that this was an ESG question and requested additional information from their contractor involved with the ESG model to ensure inflation is added to the variable associated with projecting the flat rate premium amount. To provide further context, the known rates for FY 2024 and FY 2025 are $101 and $106, each of which have about a 5% increase and further demonstrate that the results from T-PIMS are lower than expected.

Variable Rate Premiums

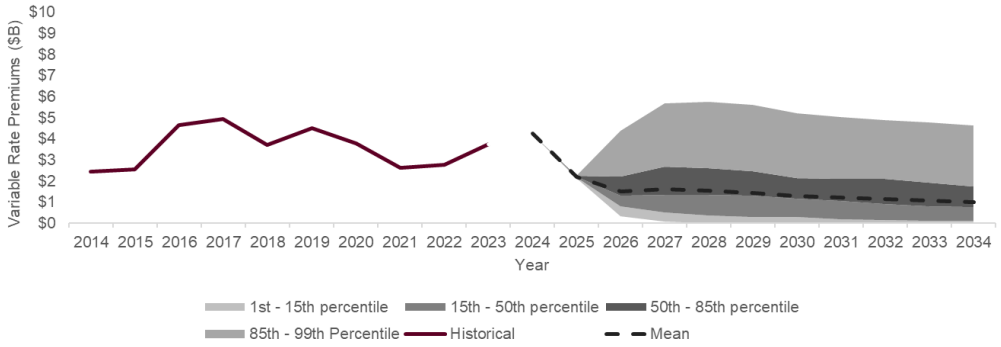
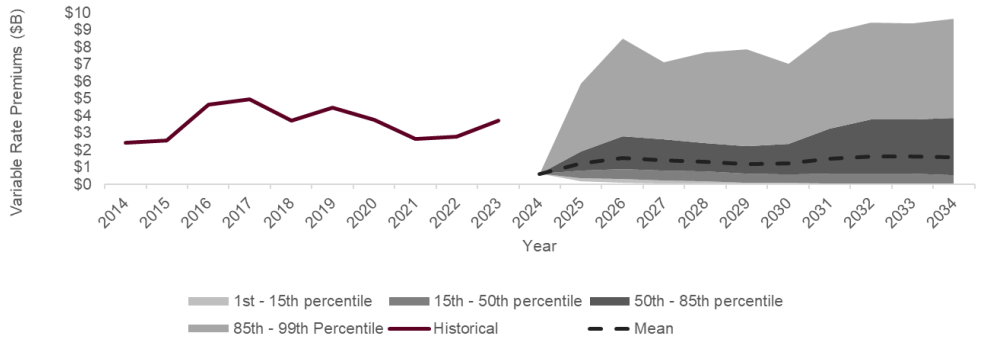
The T-PIMS model has a low starting value for variable rate premiums (VRPs) which is dramatically lower than any recent experience. This may be due to changes in plan dynamics, market shocks, or economic inputs for the most recent years. To confirm our understanding, we collaborated with PRAD to determine the driving factors causing a disconnect between starting values in the two models. The factors discussed were:

- Spikes in the interest rate and better than expected asset returns in the run up period (2021-2023 for FY 2023 results) which drove a significant drop in aggregate underfunding which leads to less VRPs
- T-PIMS did not adopt contribution changes that were reflected in Legacy PIMS between FY 2022 and FY 2023 that results in over projection of assets (better funding status) in T-PIMS
- T-PIMS has not yet implemented a VRP override that similarly takes place in the Legacy PIMS Model for the first projections year's VRP.

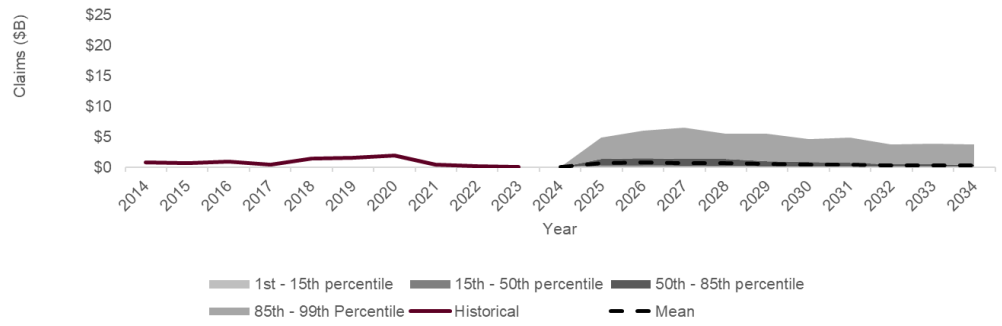
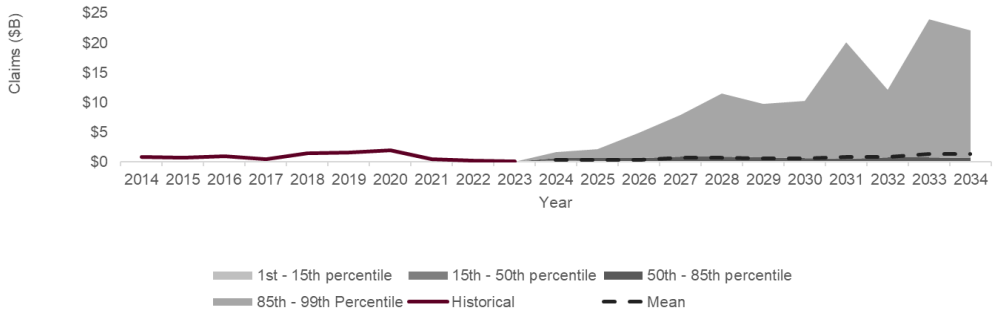
Because of these known differences it is important to consider the entire projection period. Over the time of the projection period, the T-PIMS and Legacy PIMS Models revert to align over the projection period. This suggests that while the T-PIMS model has a lower starting value both models adequately incorporate long-term trends and reversion to mean over time.

The variance in the results of the projections is also quite different between the Legacy PIMS and the T-PIMS models. The standard deviation of the historical data is .9, so we could expect a 99th percentile of around mean + 6.9 at the end of the projection period. The Legacy PIMS Model has a 99th percentile of mean + 3.6, and the T-PIMS model has a 99th percentile of mean + 8. We acknowledge that there are multiple stochastic processes combining to result in the tail dispersion of the VRP, but the T-PIMS model appears to be a better fit in terms of tail dispersion if we were to be modeling the VRPs directly.

Below we show the output for each model related to VRPs along with historical data found in the PBGC pension data tables from FY 2022, specifically table S-40.

	Figure 33. Historical and Projected Variable Rate Premiums for Legacy PIMS Model (FY 2023)  Figure 34. Historical and Projected Variable Rate Premiums for T-PIMS Model (FY 2023) 
FY 2022 Commentary	There are no material differences in premiums between FY 2022 and FY 2023 projection years other than differences caused by changes in starting values such as interest rates and participant counts. In future years, PRAD intends to implement a first year override of the VRP, and this would bring starting values in line.
SE Plan "flag" fields including Standard Termination, Annuity Purchase, VRP cap flag, and Distress Termination Flag	
Materiality	Low
Reasonableness	The reconciliation team reviewed the plan flag field outputs and found them to be generally reasonable and directionally consistent with other model results. Since the flag fields are designed to track the occurrence of specific events, rather than quantifying their financial impact, we do not expect them to be the primary drivers of changes in the aggregate projections. Instead they serve as indicators of activity within the Plan Universe, and explanations for the various financial metrics (liability reductions annuity purchases or changes in premium income due to VRP caps) are addressed elsewhere in our report.

Commentary	One enhancement offered by T-PIMS over Legacy PIMS is the inclusion of event flag fields, which track and summarize the frequency of key plan-level events across the projection period. These flags capture the number of plans each year affected by activities such as annuity purchases, reaching the VRP Cap, standard terminations, and distressed terminations. While these events could be identified through more detailed analysis or post-processing in Legacy PIMS, the new model provides a direct and transparent counting of their occurrence as part of the core output. We reviewed the flag outputs and found them generally reasonable and consistent with other model results. However, for annuity purchases the number of plans flagged appears lower than recent historical levels. T-PIMS projects about 0.48% of plans/bundles purchasing annuities annually in early years of the projection compared to a historical average of about 0.73%, and closer to 1% in recent years. Historical data was obtained using the FY 2022 PBGC pension data tables, specifically the S-54 table. For the VRP cap flags, the number of affected plans aligns with the shape of the VRP projections, for example more plans hitting the cap is associated with more VRP revenue. The number of plans flagged for VRP caps is more prominent at the higher percentiles suggesting that under more adverse conditions, a larger share of plans may be subject to the cap. The termination related flag fields, covering both standard terminations and distressed terminations, are closely tied to the bankruptcy model and termination logic studied elsewhere in our review. These appear directionally consistent with projected bankruptcy rates and show a logical relationship between plan sponsor financial distress and plan termination outcomes.
FY 2022 Commentary	There were no flag field values available for the Legacy PIMS Model for the FY 2022 projection period. We compared the FY 2022 and FY 2023 results for the T-PIMS output and observed similar trends and magnitudes for each year.
SE Plan Claims (SE PBGC Program Claims)	
Materiality	High
Reasonableness	The tail dispersion of the T-PIMS model is higher than is expected based on historical experience.
Commentary	The heavy right tail of the distribution of SE Plan Claims in the T-PIMS model is pulling the mean significantly higher than the median. In the first projection period the mean is nearly 100% higher than the median, and the differential increases with the future time steps. The dispersion of the tail in the Legacy PIMS Model (3.68 at 99th percentile) is lower than expected based on the historical data (4.68 at the 99th percentile). However, the T-PIMS 99th percentile of 22.13 is significantly higher than the 5.66 expected from the historical data and earlier time steps. The bankruptcy model is a significant factor in the heavy tail in the T-PIMS model. We recommend that PRAD review the model and consider the size of the tail and whether it is warranted considering the variability of historical data and expected future developments. It may be worth revisiting the tail behavior of the bankruptcy risk and the plans that become claims as a result to better align to recent historical experience, but if the goal is to be more

	conservative and capture more extreme event behavior, this aspect of the T-PIMS model may be seen as a strength compared to the Legacy PIMS Model. Figure 35. Historical and Projected Claims for Legacy PIMS Model (FY 2023)  Figure 36. Historical and Projected Claims for T-PIMS Model (FY 2023) 
FY 2022 Commentary	While there are differing starting points, there are no material differences between FY 2022 and FY 2023 for the T-PIMS model. We were not provided claims for FY 2022 for the Legacy PIMS Model so we were unable to verify the relationship between models for FY 2022. We did compare T-PIMS model results between fiscal years and while there was some slight variation between fiscal years, overall the results were aligned with FY 2023 results.
SE Plan Liabilities	
Materiality	High
Reasonableness	Starting values of both models appear to be low and caused by recent spikes in interest rates. The T-PIMS projections account for more variability and appear to be reasonable.
Commentary	Both the Legacy PIMS and the T-PIMS models have a low starting value for SE Plan Liabilities that is lower than any recent experience. This may be due to changes in plan dynamics, spikes in interest rates, or other abnormalities in economic inputs for the most

recent years. As noted in the above commentary about recent changes in the VRPs, atypical economic inputs, including spikes in the interest rate, drove a drop in liabilities in recent years. Regardless of the cause, it is recommended that PRAD studies the results to understand the cause and considers starting at a seed value for these projections to potentially improve early year projections if there is a bias in starting value.

During the team's review of the termination liabilities we also noticed a significant difference throughout the projection in the plan liabilities amounts across percentiles which appeared to be amplified in the upper percentiles. At the 99th percentile we note that the plan liabilities amount at the end of the projection period grows to more than double the Legacy amount ($4,350B vs $1,889B). However, the dispersion of the T-PIMS model's 99th percentile compared to the mean is reasonable considering historical data and a projection of ten time steps into the future. The Legacy model, in contrast, has unreasonably limited variability through the end of the projection period. The tail dispersion of the liability in the T-PIMS model is the most likely driven by model specifications and how the negative yield curve at lower end interest rate scenarios is affecting the projection. The significant disparity between models warrants our recommendation that PRAD considers further testing and assess whether they can describe scenarios that would result in the tail behavior seen at the 99th percentile.

The updated T-PIMS run brought projected Termination Liabilities substantially closer to the values produced by the Legacy Model. This adjustment also addressed some prior concerns regarding the tail behavior of the T-PIMS projections. With the revised run, the extreme high-end values have come down, resulting in tail behavior that appears more consistent with plausible outcomes. Overall, the update enhanced the credibility of the T-PIMS projections for termination liabilities by aligning both central estimates and distributional characteristics more closely with historical expectations and the Legacy model output.

Figure 37. Historical and Projected Plan Liabilities for Legacy PIMS Model (FY 2023)

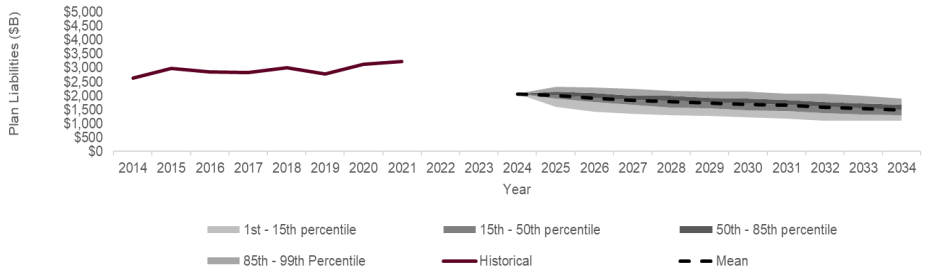
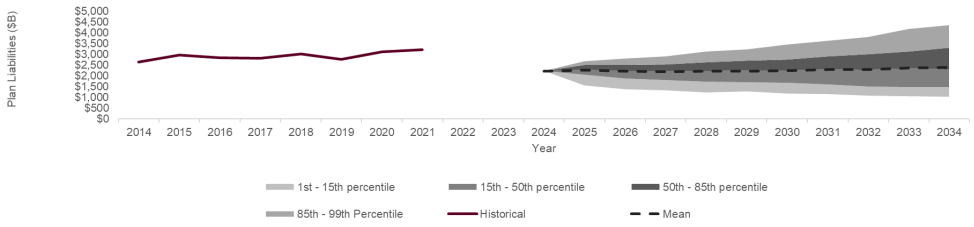


	Figure 38. Historical and Projected Plan Liabilities for T-PIMS Model (FY 2023) 
FY 2022 Commentary	Our review of the FY 2022 results for the plan liabilities led us to similar conclusions as our FY 2023 review. FY 2022 showed similar trends but was less impacted by tail behavior.
PBGC SE Program Fields	
PBGC SE Program Assets, Liabilities, and Net Position	
Materiality	High
Reasonableness	The T-PIMS Assets, Liabilities, and Net Position are Reasonable
Commentary	When comparing these final results, the Assets, Liabilities, and Net Position, of the PBGC SE Program, it is important to recognize that these fields represent the net result of the build-up from all of the base level fields and modeling. Evaluating the results of these fields simply by comparing the T-PIMS model to the Legacy PIMS Model may not fully evaluate the appropriateness of the T-PIMS model in aggregate. This measure may be misleading, as the final outcomes are shaped by all of the assumptions and methods employed in the lower levels of the model. When comparing the final results of the T-PIMS model to the Legacy PIMS Model, we looked at the relationship between the results, but also considered how well the base model assumptions, methods, and modeling results aligned with the historical and current risk environments. An additional point to consider is that the final results of the model, such as the tail experience of the Net position after 10 years, are stochastic in nature and highly dependent on the base model assumptions and the intermediate layering of the model to build up to this point. In this context, differences between the models are expected due to the significantly updated model parameters. While these differences can be evaluated by comparing the mean values of the ending results, we also evaluated them in terms of their impact on the PBGC's core objectives, such as ensuring adequate premium and avoiding negative net positions in the future. The best measure of a model used to measure and mitigate future risk is its ability to reflect the evolving realities of complex systems. *Overall, the updated T-PIMS run did not make a major impact on the results of PBGC assets, liabilities, or net position. There were slight improvements observed from the new T-PIMS run but the overall impact was limited.* <u>PBGC Assets</u> The mean value of the assets at the end of the projection period from the T-PIMS model is within 5% of the mean value from the Legacy PIMS Model. This close alignment is a positive indication that both models are producing broadly similar overall results. It is noted that at the 99th percentile of the tail, the T-PIMS model is 20% above the Legacy PIMS

Model. Below we show the projection of PBGC assets for each model as compared to recent historical results as found in the PBGC Pension Data tables, specifically the S-1 table.

Figure 39. Historical and Projected PBGC Assets for Legacy PIMS Model (FY 2023)

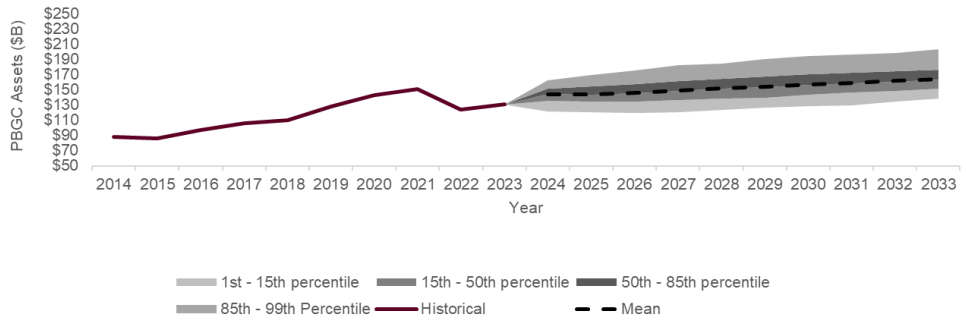
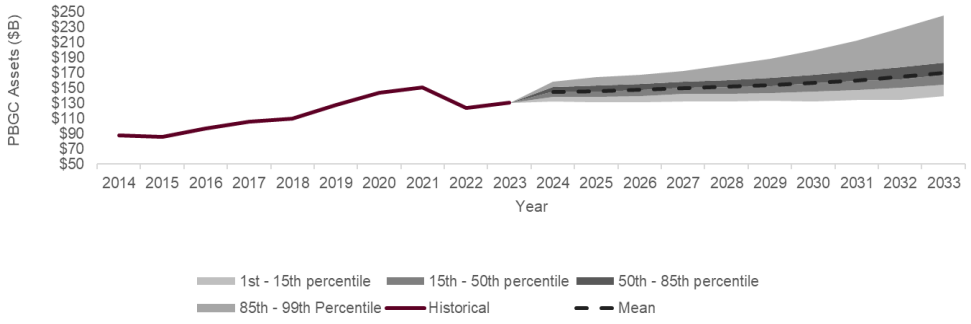


Figure 40. Historical and Projected PBGC Assets for T-PIMS Model (FY 2023)



PBGC Liabilities

The liability results reflect a higher risk sensitivity than the assets. The T-PIMS model is 14% lower than the Legacy PIMS Model at the mean, but 43% higher at the 99th percentile. This pattern reflects the model's improved sensitivity to risk processes that feed into the determination of the PBGC liabilities, especially in areas such as bankruptcy and claims, and the accumulation of variation throughout the projection period is consistent with how we expect these risks to develop over time. The main drivers of differences between the models are the underlying stochastic processes discussed and compared above. Below we show the projection of PBGC liabilities for each model as compared to recent historical results as found in the PBGC Pension Data tables, specifically the S-1 table.

Figure 41. Historical and Projected PBGC Liabilities for Legacy PIMS Model (FY 2023)

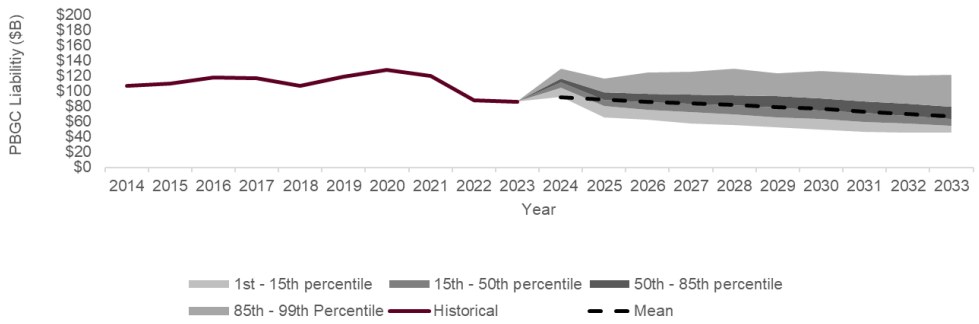
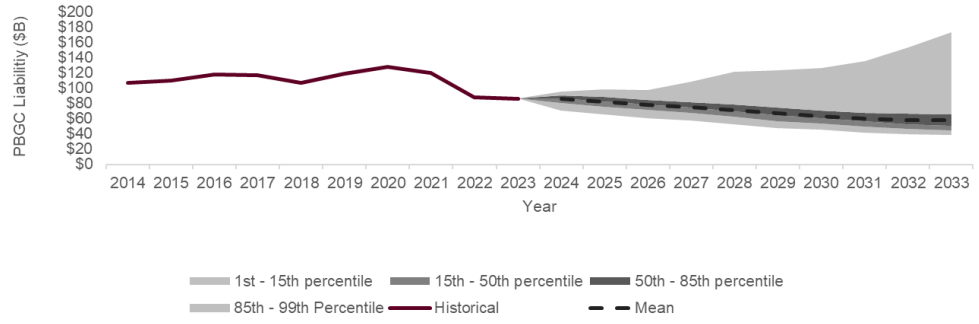


Figure 42. Historical and Projected PBGC Liabilities for T-PIMS Model (FY 2023)



PBGC Net Position

The mean net position of the T-PIMS model is 15% higher than the net position of the Legacy PIMS Model at the end of the projection period. At the 99th percentile, the T-PIMS model is 25% higher than the Legacy PIMS Model at the end of the projection period. The T-PIMS model has greater spread in tail dispersion throughout the underlying stochastic processes as discussed above and appears to be better fit to recent observed levels of variation in tail behavior. While the Legacy PIMS Model is well-established and has historically provided reliable results, it exhibits less sensitivity to extreme scenarios. Given that the SE projection model is measuring risk inherent in the benefits provided by the PBGC, the T-PIMS model is likely an improvement over the Legacy PIMS Model to support well-informed risk mitigation and management.

Figure 43. Historical and Projected PBGC Net Position for Legacy PIMS Model (FY 2023)

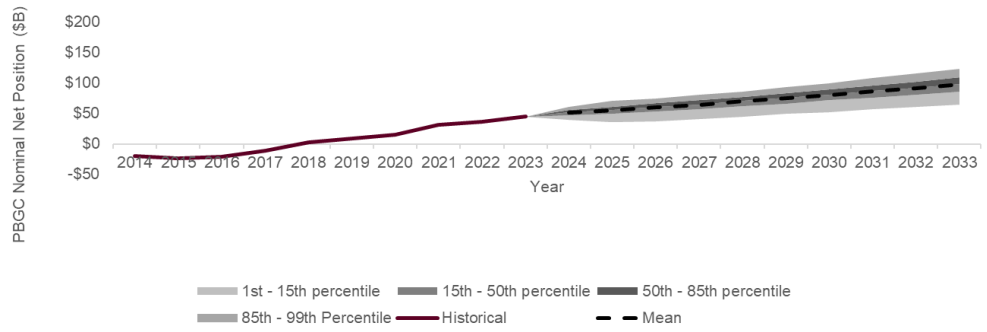
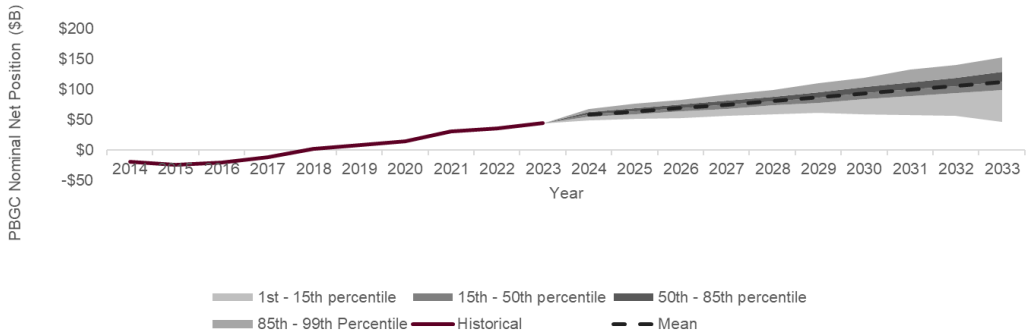


Figure 44. Historical and Projected PBGC Net Position for T-PIMS Model (FY 2023)



FY 2022 Commentary

Our FY 2023 analysis of the PBGC SE Program Assets, Liabilities, and Net position led us to determine that the differences between models were reasonable and that the T-PIMS model was potentially capturing tail behavior more effectively than the Legacy PIMS Model.

There were no material differences when comparing the FY 2022 projection year results to the FY 2023 projection year results for the T-PIMS model. Differences in the Legacy PIMS Model are driven by the Legacy PIMS Model results for the FY 2022 projection year. In regard to the FY 2022 output we noticed that the percentage difference between models for both the hedged PBGC assets and Risk Seeking Assets (RSA) were the same. This led us to conclude that those results could not be fully relied on to conclude reasonability. PRAD should look into the FY 2022 results for PBGC assets to understand why both funds saw the same return while should be modeled differently.

Future Considerations

As the PRAD team begins the process of updating the ME Legacy model to a ME T-PIMS model, several insights emerged that should inform both the continued development of the SE T-PIMS model as well as the ME T-PIMS model:

1. As model variables are calibrated to historical experience, consider the spread of the tail risk and whether it matches historical data. Because the model is used to assess the adequacy of the program over long periods of time, the tail of the projections should have large enough spread to incorporate significantly adverse conditions. Historical data played a key role in increasing confidence in the SE T-PIMS model, especially in cases where output diverged from the Legacy model results. In several instances, the wider tail behavior observed in the T-PIMS model better reflected real-world experience and risk profile variability, highlighting the improved realism of the updated model framework.
2. Validation and Predictive testing: To improve future model calibration, it may be beneficial to hold out the final one or two years of historical data during development. This would allow for out-of-sample validation and more robust testing of predictive accuracy as the model is being developed. Additionally, annual back-testing should be established as a formal exercise to continue monitoring the model's fit and predictive strength.
3. Sensitivity testing of novel model input sources is recommended. Key differences in model inputs should be considered prior to using them in the model. Assumptions used in selecting key inputs that the model is highly sensitive to should be discussed and selected carefully at the outset of model building. While we understand that PRAD intends to shift to using 5500 filing information for benefit payments as an input into the T-PIMS model, the appropriateness of using the 5500 filing benefit payment streams should be assessed when the initial year of data becomes available.
4. Involving an independent model validation team with both economists and actuaries significantly enhanced our understanding of the underlying pension plan modeling as well as the Economic Scenario Generator. This multidisciplinary approach facilitated a comprehensive analysis of the longer term projections of liabilities and assets, as well as assessing the reasonability of the bankruptcy model. Given the effectiveness of this collaboration, it is strongly recommended to replicate this integrated methodology in future reviews to ensure roust and informed model testing.

Evaluation of T-PIMS Model Reliability

As noted in the introduction, the T-PIMS model overall appears to be generally reasonable and reliable for use, and can be relied upon to replace the Legacy PIMS Model to project the net position of the PBGC SE program over a multi-year time horizon. We understand that further parallel testing of the T-PIMS model is planned over the next year. Considering this, we recommend that the following areas be considered as the final testing is completed:

1. Variable Rate Premiums produce an anomalous starting value. We suggest potentially initializing this variable with seed values based on current state data to improve early projection year accuracy.
2. Once the new benefit payment methodology is implemented in T-PIMS starting in FY 2024, PRAD should prioritize studying plan benefit payment differences between model results. Although the new source of benefit payments is expected to be an improvement, careful, targeted testing of this component will be essential to validate the T-PIMS performance with all inputs available. The model was found to be sensitive to this input.
3. There are also a few variables, such as claims, that are heavily impacted by rare or uncommon events where the mean output is being pulled significantly away from the median. We recommend close consideration of the standard deviation of these variables to avoid overestimating the potential for significantly adverse events.
4. Consider performing detailed testing to determine the reason for the minor difference in the plan liability by the T-PIMS model. Is it coming from Tier 1 plans, the big Tier 2 plans, or the bundled Tier 2 plans? Are the results for FY 2022 consistent with the results from FY 2023 or FY 2021?

In conclusion, while the T-PIMS model has opportunity for additional refinement, it is a strong foundation for future use. It is generally suitable for its intended role in assessing the financial position of the PBGC Single Employer program and assisting policy makers with understanding the risks inherent in the program.

As part of the broader transition to the T-PIMS model framework, several supporting steps should be undertaken to ensure long-term success and sustainability:

1. Model Documentation: Develop comprehensive documentation outlining the model's methodology, assumptions, data sources, governance framework, sensitivity profiles, and known limitations. This should include a model user guide for team members who will be running the model and a more brief model summary document for external stakeholders.
2. Governance and Monitoring Framework: Establish a formal model governance schedule, including regular performance reviews, calibration checks, and scenario testing protocols. Assign clear ownership for maintaining the model and associated documentation.
3. Legacy Model Archival: Finalize plans for decommissioning and archiving the Legacy model, including documentation of differences and transition rationale as well as potential limited-use scenarios if any remain. Any residual use cases for the Legacy PIMS model should be clearly defined and time-bound. Otherwise, a decommissioning date should be selected and held as the clear transition point between models.

4. Define Key Performance Indicators (KPIs): Identify metrics to monitor model performance over time, such as variance from actual experience, input volatility impacts, or total runtime. Tracking these metrics over time will help flag emerging issues and prompt model maintenance.

These steps will help ensure that the T-PIMS model not only performs well today but remains well-governed, transparent, and adaptable to changing economic environments over time.

Appendix

Figure 45. Average Cumulative Default Rate (Without De-risking) for Legacy PIMS and T-PIMS (FY 2023)

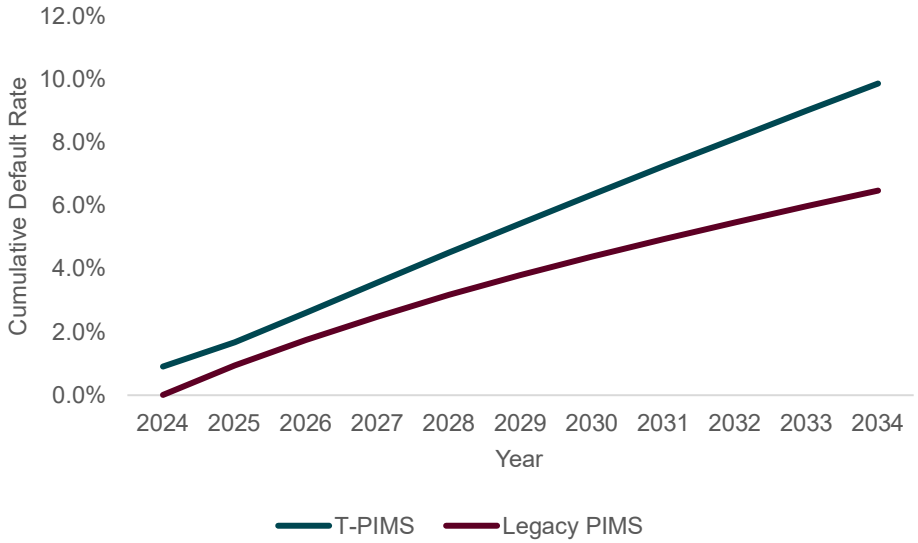


Figure 46. BB Historical and T-PIMS Transition to Default (FY 2023)

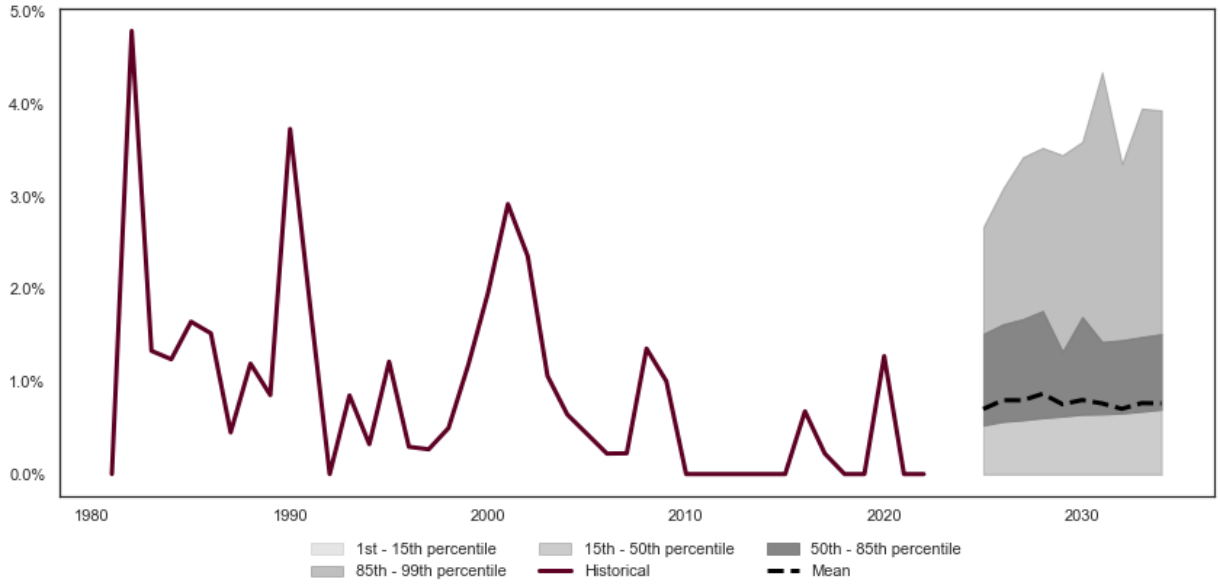
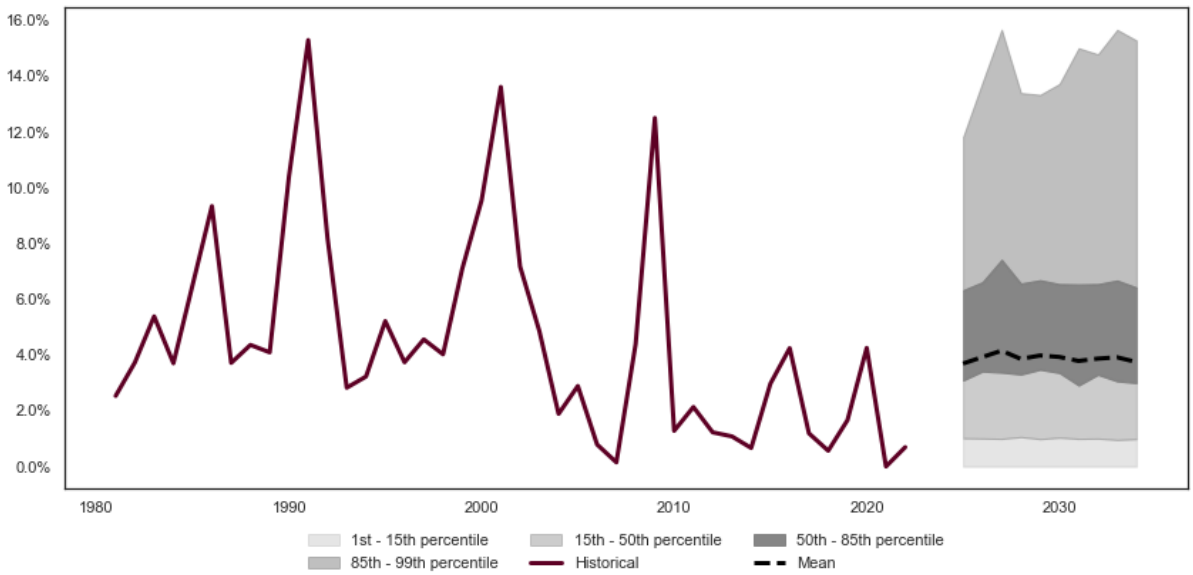


Figure 47. B Historical and T-PIMS Transition to Default (FY 2023)



FY 2023 Reconciliation

Table 5. Comparison of final year mean projected amounts ($B) between Legacy PIMS and T-PIMS (FY 2023)

Model Output (PBGC Fields)	SE Legacy PIMS Output	T-PIMS Output	% Variation
PBGC SE Program Nominal Net Position	$97.1	$112.4	15.75%
PBGC SE Program PV Net Position	$66.5	$76.7	15.32%
PBGC SE Program Total Assets	$164.4	$170.3	3.60%
PBGC SE Program Assets (Hedged)	$141.0	$144.8	2.67%
PBGC SE Program Assets (RSA)	$23.4	$25.5	9.21%
PBGC SE Program liability	$67.3	$57.9	-13.93%
PBGC SE Program Claims	$0.3	$1.2	376.03%
PBGC SE Program Benefit Payments	$7.0	$4.8	-31.54%
PBGC SE Program Flat rate premiums	$1.9	$1.8	-5.21%
PBGC SE Program Variable rate premiums	$1.0	$1.6	58.44%
PBGC SE Program Total Premium	$2.9	$3.4	16.54%
PBGC SE Program Expenses	$0.6	$0.5	-18.33%
PBGC SE Program Asset return $	$7.5	$7.3	-3.19%
PBGC SE Program Asset return %	4.80%	4.40%	-8.15%
PBGC SE Program single eqvlt liab interest rate	4.61%	4.58%	-0.70%
Model Output (Plan Fields)	**SE Legacy PIMS Output**	**T-PIMS Output**	**% Variation**
SE Plan Market Value of Assets	$1,924.8	$2,716.8	41.15%
SE Plan Funding Target	$1,437.2	$1,868.7	30.02%
SE Plan Target Normal Cost	$34.0	$67.7	98.97%
SE Plan Benefit Payments	$117.3	$118.0	0.58%
SE Plan Minimum Required Contribution	$9.2	$62.3	581.18%
SE Plan Assumed Contribution (based on policy)	$32.8	$68.4	108.76%
SE Plan Total P-count	11.6M	15.9M	37.41%
SE Plan Active Count	3.3M	4.2M	26.33%
SE Plan TV Count	2.2M	4.7M	114.49%
SE Plan Retiree Count	6.1M	7M	15.81%
SE Plan Flat rate premiums	$1.9	$1.8	-5.24%

SE Plan Variable rate premiums	$1.0	$1.6	58.37%
SE Plan VRP Cap Flag	Not Available	127.9 plans	Not Available
SE Plan Standard Termination Flag	Not Available	16.1 plans	Not Available
SE Plan Annuity Purchase Flag	Not Available	75.4 plans	Not Available
SE Plan T4 Liability	$1,482.8	$2,391.2	61.26%
SE Plan Plan Expenses	$6.1	$7.0	15.70%
SE Plan Asset return $	$110.2	$182.5	65.58%
SE Plan Asset return %	6.50%	6.10%	-6.47%
SE Plan PBGC single equivalent liability interest rate	4.60%	4.60%	-0.70%
SE Plan Bankruptcy rate	0.50%	1.00%	97.25%
SE Plan Claims	$0.3	$1.2	376.34%
SE Plan Distress Termination Flag	Not Available	3.5 plans	Not Available

FY 2023 Reconciliation with Benefit Payment Assumption Update

Table 5. Comparison of final year mean projected amounts ($B) between Legacy PIMS and T-PIMS (FY 2023)

Model Output (PBGC Fields)	SE Legacy PIMS Output	T-PIMS Output	% Variation
PBGC SE Program Nominal Net Position	$97.1	$111.6	14.97%
PBGC SE Program PV Net Position	$66.5	$76.1	14.38%
PBGC SE Program Total Assets	$164.4	$167.1	1.63%
PBGC SE Program Assets (Hedged)	$141.0	$142.0	0.71%
PBGC SE Program Assets (RSA)	$23.4	$25.1	7.13%
PBGC SE Program liability	$67.3	$55.4	-17.63%
PBGC SE Program Claims	$0.3	$0.6	147.02%
PBGC SE Program Benefit Payments	$7.0	$4.7	-32.51%
PBGC SE Program Flat rate premiums	$1.9	$1.8	-7.20%
PBGC SE Program Variable rate premiums	$1.0	$0.5	-45.15%
PBGC SE Program Total Premium	$2.9	$2.3	-20.22%
PBGC SE Program Expenses	$0.6	$0.5	-18.33%
PBGC SE Program Asset return $	$7.5	$7.3	-3.22%
PBGC SE Program Asset return %	4.80%	4.40%	-8.15%
PBGC SE Program single eqvlt liab interest rate	4.61%	4.58%	-0.70%
Model Output (Plan Fields)	**SE Legacy PIMS Output**	**T-PIMS Output**	**% Variation**
SE Plan Market Value of Assets	$1,924.8	$2,321.0	20.58%
SE Plan Funding Target	$1,437.2	$1,582.1	10.08%
SE Plan Target Normal Cost	$34.0	$81.9	140.80%
SE Plan Benefit Payments	$117.3	$113.6	-3.10%
SE Plan Minimum Required Contribution	$9.2	$52.7	476.06%
SE Plan Assumed Contribution (based on policy)	$32.8	$42.6	29.98%
SE Plan Total P-count	11.6M	15.3	32.13%
SE Plan Active Count	3.3M	4.2	26.33%
SE Plan TV Count	2.2M	3.9	77.33%
SE Plan Retiree Count	6.1M	7.2	19.01%
SE Plan Flat rate premiums	$1.9	$1.8	-7.22%

SE Plan Variable rate premiums	$1.0	$0.5	-45.17%
SE Plan VRP Cap Flag	Not Available	64.6	Not Available
SE Plan Standard Termination Flag	Not Available	16.8	Not Available
SE Plan Annuity Purchase Flag	Not Available	77.5	Not Available
SE Plan T4 Liability	$1,482.8	$1,702.7	14.83%
SE Plan Plan Expenses	$6.1	$7.2	18.02%
SE Plan Asset return $	$110.2	$152.2	38.05%
SE Plan Asset return %	6.50%	6.10%	-6.55%
SE Plan PBGC single equivalent liability interest rate	4.60%	4.60%	-0.70%
SE Plan Bankruptcy rate	0.50%	1.00%	97.23%
SE Plan Claims	$0.3	$0.6	147.18%
SE Plan Distress Termination Flag	Not Available	3	Not Available

FY 2022 Reconciliation

Table 6. Comparison of final year mean projected amounts ($B) between Legacy PIMS and T-PIMS (FY 2023)

Model Output (PBGC Fields)	SE Legacy PIMS Output	T-PIMS Output	% Variation
PBGC SE Program Nominal Net Position	$79.6	$106.3	33.57%
PBGC SE Program PV Net Position	$54.5	$72.8	33.65%
PBGC SE Program Total Assets	$143.0	$172.1	20.33%
PBGC SE Program Assets (Hedged)	$121.6	$146.3	20.34%
PBGC SE Program Assets (RSA)	$21.5	$25.8	20.32%
PBGC SE Program liability	$63.4	$65.8	3.74%
PBGC SE Program Claims	$0.2	$1.0	457.89%
PBGC SE Program Benefit Payments	$6.9	$5.5	-21.06%
PBGC SE Program Flat rate premiums	$2.0	$1.9	-8.25%
PBGC SE Program Variable rate premiums	$0.6	$1.5	159.09%
PBGC SE Program Total Premium	$2.6	$3.4	29.38%
PBGC SE Program Expenses	$0.6	$0.5	-11.50%
PBGC SE Program Asset return $	$6.1	$6.9	12.24%
PBGC SE Program Asset return %	4.60%	4.10%	-11.27%
PBGC SE Program single eqvlt liab interest rate	4.70%	4.70%	0.00%
Model Output (Plan Fields)	**SE Legacy PIMS Output**	**T-PIMS Output**	**% Variation**
SE Plan Market Value of Assets	$2,148.1	$2,203.9	2.60%
SE Plan Funding Target	$1,360.0	$1,540.2	13.25%
SE Plan Target Normal Cost	$32.0	$65.8	105.75%
SE Plan Benefit Payments	Not Available	$114.4	Not Available
SE Plan Minimum Required Contribution	$5.7	$56.8	895.66%
SE Plan Assumed Contribution (based on policy)	$39.1	$59.2	51.47%
SE Plan Total P-count	12.7M	16.5M	29.92%
SE Plan Active Count	3.9M	4.4M	13.26%
SE Plan TV Count	2.3M	4.9M	110.17%
SE Plan Retiree Count	6.5M	7.2M	10.55%
SE Plan Flat rate premiums	$1.8	$1.9	4.16%

SE Plan Variable rate premiums	$0.6	$1.5	155.97%
SE Plan VRP Cap Flag	Not Available	115 plans	Not Available
SE Plan Standard Termination Flag	Not Available	15.5 plans	Not Available
SE Plan Annuity Purchase Flag	Not Available	74 plans	Not Available
SE Plan T4 Liability	$1,446.9	$2,020.9	39.67%
SE Plan Expenses	Not Available	$11.5	Not Available
SE Plan Asset return $	$120.6	$115.5	-4.23%
SE Plan Asset return %	Not Available	4.90%	Not Available
SE Plan PBGC single equivalent liability interest rate	Not Available	4.70%	Not Available
SE Plan Bankruptcy rate	Not Available	1.00%	Not Available
SE Plan Claims	Not Available	$1.0	Not Available
SE Plan Distress Termination Flag	Not Available	3.3 plans	Not Available

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