ADVANCED ANALYTICAL
CONSULTING GROUP

EMPLOYER CONTRIBUTIONS IN SE-PIMS

March 19, 2021

Advanced Analytical Consulting Group, Inc.

Constantijn W.A. Panis, PhD
213-784-6400
stanpanis@aacg.com

Karthik Padmanabhan, MS, MBA
312-551-9001
karpad@aacg.com

SUMMARY

The Pension Benefit Guaranty Corporation (PBGC) insures participants in private pension plans against loss of some or all benefits in case their plan is unable to pay benefits. The agency uses a stochastic modeling system, the Single-Employer Pension Insurance Modeling System (SE-PIMS), to make projections of future expected liabilities related to single-employer plans. Future expected liabilities depend, in part, on annual employer contributions to single-employer pension plans.

This report evaluates the current model to project employer contributions on the basis of the correlation between in-sample projected and actual contributions. We develop several alternative models, including a single-equation statistical model with four explanatory variables: target normal cost, the marginal rate of the Variable Rate Premium, the return on equities, and plan size. This alternative model outperforms the current model.

Annual aggregate employer contributions have fluctuated substantially in recent years. As a result, the recent past offers incomplete guidance for the level of future annual aggregate contributions. PBGC addressed this issue by targeting a plausible value of future aggregate contributions. We agree with that solution, but recommend that an analysis be carried out to gauge the sensitivity of PBGC's financial outlook to alternative plausible values.

CONTENTS

1. INTRODUCTION

The Pension Benefit Guaranty Corporation (PBGC) retained Advanced Analytical Consulting Group, Inc. (AACG) to conduct a review of certain aspects of PBGC's Single-Employer Pension Insurance Modeling System (SE-PIMS). This report reviews the current modeling of employer contributions of single-employer defined benefit (DB) pension plan sponsors.

The remainder of this report is organized as follows. It starts with a discussion of the legal boundaries around employer contributions. Section 2 describes how the current version of SE-PIMS projects employer contributions and discusses its strengths and weaknesses. Section 3 defines a concept that we consider central to modeling employer contributions, documents historical contributions, and develops evaluation criteria to gauge the performance of the current and potential alternative models. Section 4 develops an alternative model and evaluates its performance. Section 5 concludes with recommendations for the model and a sensitivity analysis.

Legal Framework

This subsection provides a high-level overview of our understanding of legal requirements related to employer contributions. It is not intended to be exhaustive and does not discuss special provisions.

The Internal Revenue Code (IRC) and related regulations place a lower limit and an upper limit on annual employer contributions. The Minimum Required Contribution (MRC) is the sum of three components minus one component (26 CFR § 1.430(a)-1):

- *Target Normal Cost (TNC)*: present value of benefits expected to be earned over the plan year, plus plan expenses, minus employee contributions (if applicable).
- Minus *Excess Assets*: the amount, if any, by which assets (reduced by credit balances) exceed the present value of future benefits may be subtracted to calculate the MRC. The amount that may be subtracted cannot exceed the TNC.
- Plus *Shortfall Amortization Charge*: Plans with a funding shortfall are required make contributions intended to reduce the shortfall over a period of seven years.
- Plus *Waiver Amortization Charge*: If the Secretary of the Treasury granted to a plan a waiver to make the MRC in a prior year, the missed contributions must be made up over a period of five years.

Congress has periodically provided funding relief by tweaking actuarial parameters in ways that lower the MRC. For example, the Pension Relief Act of 2010 (PRA) allowed plans to amortize a funding shortfall over a period of longer than seven years. Separately, the Moving Ahead for Progress in the 21st Century Act of 2012 (MAP-21) connected discount rates to 25-year historical averages, effectively increasing the rates, reducing liabilities, and reducing the MRC. Relief measures generally phase out over time, but may be extended, as the Highway and Transportation Funding Act of 2014 (HATFA) and the Bipartisan Budget Act of 2015 (BBA) did for the relief provided by MAP-21. Most recently, the American Rescue Plan Act of 2021 extended the underfunding amortization period from seven to 15 years.

If a plan contributes more than the MRC, it accumulates a credit balance which may be applied toward the MRC in a future year. Credit balances accumulated before 2008 are known as carryover balances, while those accumulated in 2008 or later are known as prefunding balances.

In general, contributions made to a plan are tax deductible. However, while tax deductions may incentivize sponsors to contribute more than the MRC, it may be costly to overfund a plan. Deductible contributions are limited to the sum of the funding target, target normal cost, and a cushion amount (that accounts for future increases in participant benefits) minus the value of assets in the plan (26 USC §404(o)). Nondeductible contributions are subject to an excise tax of 10% (26 USC §4972). Also, any assets that are returned from the plan to the sponsor are subject to a 50% reversion tax, or a 20% reversion tax if a qualified replacement plan is established or the sponsor increases benefits (26 USC §4980).

2. CURRENT APPROACH TO PROJECTING EMPLOYER CONTRIBUTIONS

It is our understanding that the current model was first implemented in support of the FY 2019 Projections Report.[1] The description in this section is based on pages 39–42 of that report and several iterations of PBGC-internal documents. The most recent version we reviewed was titled "PRAD Single Employer Contribution Policy Assumption for PIMS, 2020 – Behavioral Incentives", last modified on July 16, 2020 ("PBGC Memo").

The current approach distinguishes between five contribution strategies which apply, individually or in combinations, to five states of plan funding. It may be viewed as a decision tree or a flow chart. A plan follows one of five branches, depending on a plan's state of funding. Each of the five branches splits into between one and four sub-branches, which represent contribution strategies. Each of those contribution strategies may split into multiple sub-subbranches, typically depending on a certain measure of the funded ratio. The ultimate employer contribution is a weighted average of amounts for each relevant strategy or the maximum of several such amounts.

The five states of plan funding are:[2]

- Funded at 0%–70% by PPA standards;
- Funded at 70%–75% by PPA standards;
- Funded at 75%–80% by PPA standards;
- Funded at more than 100% of Vested Benefits Liability (VBL) in any of the prior three years;
- Funded at less than 100% of VBL.

Depending on the state of plan funding (level 1 branch), the plan is assumed to contribute a weighted average of amounts dictated by various contribution strategies (level 2 branch). The five contribution strategies are named after the concepts by which they are guided:

---

[1] https://www.pbgc.gov/sites/default/files/fy-2019-projections-report.pdf

[2] In addition, SE-PIMS recognizes a sixth plan funded status, namely for plans that terminate in distress. When SE-PIMS projects a plan to file a claim with PBGC, it erases the last year of contributions (*PIMS System Description*, Section 4.2.8).

- Minimum Required Contribution (MRC): Contribute only the MRC using 90% of the available credit balance and the remainder in cash. This strategy is a refined version of the default strategy of previous SE-PIMS models.
- Adjusted Funding Target Achievement Percentage (AFTAP): Contribute an amount that ensures the AFTAP is equal to 80%.
- Unfunded Vested Benefits Liability (UVBL): Contribute a percentage of the UVBL, as if to amortize the unfunded liability. The applicable percentage is determined through a level 3 branch: if the VBL funded percentage is less than 60%, contribute 10% of UVBL; between 60% and 80% contribute 15% of UVBL; between 80% and 85% contribute 25% of UVBL; between 85% and 90% contribute 33.3% of UVBL; between 90% and 95% contribute 50% of UVBL; and between 95% and 100% contribute 100% of UVBL.
- Target Normal Cost (TNC): Contribute a multiple of TNC. Specifically, if the VBL funded percentage is less than 100%, contribute 150% of TNC; between 105% and 110%, contribute 140% of TNC; between 110% and 115%, contribute 130% of TNC; between 115% and 120%, contribute 120% of TNC; between 120% and 130%, contribute 110% of TNC; and if the VBL funded percentage exceeds 130%, contribute 100% of the TNC.
- Maximum Percentage over the past 3 years (MAXP3): If the VBL funded percentage is lower than the maximum over the past three years, contribute an amount that erases a fraction of the erosion. Specifically, if the VBL funded percentage is less than 110%, contribute 30% of the erosion; between 110% and 115%, contribute 25% of the erosion; and over 115%, contribute 20% of the erosion.

Table 1 summarizes the contribution strategies that apply to each of the five plan funding states in the 2019 SE-PIMS. For example, all plans that are less than 70% funded by PPA standards are assumed to follow the MRC strategy, and plans that are 70%–75% funded by PPA standards are assumed to contribute 50% of the amount stipulated by the MRC strategy plus 50% of the amount stipulated by the AFTAP strategy.

Table 1. Assumed Contribution Strategies by Plan Funded State

			Contribution strategy				
Rule	Funded level	Target	MRC	AFTAP	UVBL	MAXP3	TNC
PPA	0%–70%	80% PPA TL	100%				
PPA	70%–75%	80% PPA TL	50%	50%			
PPA	75%–80%	80% PPA TL		100%			
VBL	100%+ in last 3 years	100% MAXP3			Maximum of UVBL, MAXP3, TNC		
VBL	<100%	100% VBL	0%–50%*		50%–100%* of UVBL+MAXP3		

* Adjusted for VRP rate; see text below.

The last plan funding state is assumed to contribute a weighted average of the MRC and UVBL/MAXP3 strategies, where the weights are determined by a plan's applicable VRP rate. Recall that the UVBL strategy assumes that the plan contributes a portion of its UVBL. The idea is that no plan would erase a portion of its UVBL if the VRP rate were 0% because there would be no incentive to reduce the UVBL, and that all plans would immediately erase any UVBL if the VRP rate were 10%. The assumption is that, at a VRP rate of 3% ($30 per $1,000 UVBL), plans would contribute 50% of the MRC and 50% of the UVBL strategy amounts, with greater weight toward the UVBL amount if the VRP rate exceeds 3%. Specifically, the UVBL weight is equal to 50% + (rate – 3%)/(10%-3%) x 50%. The UVBL weight is capped at 100% for VRP rates in excess of 10%. For example, at a VRP rate of 5%, the plan would contribute 50% + (5%-3%)/(10%-3%) x 50% = 64.3% of the UVBL amount and the remaining fraction, 35.7%, of the MRC amount. If a plan is at the VRP cap, an "effective VRP rate" is calculated as the ratio of capped VRP to UVBL. The rate applicable to a poorly funded plan at the VRP cap is thus lower than that of a better funded plan, implying lower contributions, as observed in practice.

The "amortization rates" are similarly adjusted upward should the VRP rate exceed 6% ($60 per $1,000 unfunded). If the unadjusted amortization rate is X%, then the adjusted rate is X% + (VRP%-6%)/(10%-6%) x (100%-X%). For example, if the VRP rate were 6.5%, the 25% amortization rate (applicable to 80%–85% VBL-funded plans) would become 25% + (6.5%-6%)/(10%-6%) x (100%-25%) = 34.4%. The VRP rate, currently 4.5%, increases with inflation; current 10-year projections end with the mean VRP rate at a little above 6%.

Strengths and Potential Weaknesses of the Current Model

The current approach toward employer contribution modeling distinguishes five contribution strategies, which are applicable depending on five funding states. Among the strengths of the current approach are the following aspects.

First, the strategies explicitly tie employer contributions to target amounts that may be meaningful to many plan sponsors. For example, the MRC is a legally required contribution amount; contributing less would require a formal waiver and trigger elevated scrutiny from PBGC. Also, the target amount may be the amount needed to fund to an AFTAP of 80%; contributing less would invoke restrictions on a plan's ability to offer lump sums, purchase annuities, and other transactions. Because the target amounts are meaningful, plan sponsors are more likely to contribute those specific amounts than other amounts. The assumptions may therefore be consistent with common behaviors.

Second, the strategies are extraordinarily detailed in their account of issues that may drive sponsor decisions about contribution amounts. The discussion of the assumptions above illustrates the many factors that employers are assumed to consider. For example, if the funded level exceeded 100% in the prior three years, the contribution is assumed to be the maximum of three amounts which involve an amortization of unfunded benefits, a multiple of the Target Normal Amount, and a fraction of the amount required to reach the highest funded level of the past three years, where the amortization percentage, multiple, and fraction each depend on the funded ratio. The level of detail suggests that the assumptions are the result of careful evaluation of the types of factors that plan sponsors consider when choosing a contribution amount.

The current approach also has potential weaknesses.

First, the current approach was presumably developed using historical data by tweaking parameters until the projections were reasonably concordant with aggregate actual contributions. However, there may be many sets of parameters that produce similar levels of historical accuracy and it is unclear how sensitive the results are to assumptions about the many detailed parameters. That may not matter if the future distribution of factors that drive contributions were similar to the historical distribution, but such stationarity is unlikely to hold, in part because SE-PIMS projects thousands of scenarios, including unlikely events.

Second, the current approach does not allow contributions to vary based on certain factors that are likely to affect contributions, such as corporate profitability. A PBGC-internal memorandum acknowledged that the model does not account for financial metrics of the plan sponsor, but notes that bankruptcy probability as a parameter to drive behavior did not affect the results.[3] In contrast, a prior study found that corporate cash holdings (as a fraction of total debt) did affect employer contributions.[4] Also, the VRP plays only a small role, namely to adjust the weights applied to the MRC and alternative amounts. One of the objectives of the VRP is to provide an incentive for plan sponsors to reduce underfunding, and that incentive is stronger than it has been at any moment in the past because the VRP is higher than before and, for some plan sponsors, higher than their cost of borrowing. The VRP was designed to affect contributions.

Third, the current approach is complex in the sense that its decision tree features many branches and sub-branches. However, only a small number of concepts drive the path through the decision tree: funded ratio, unfunded liability, and Target Normal Cost.[5] It may be worth exploring whether very similar results can be achieved with a less complex model that is easier to understand.

Finally, the assumptions are deterministic rather than stochastic. The employer contributions of two plans in identical circumstances will be projected to be identical, where in reality they would likely differ. As a stochastic model, SE-PIMS is designed to explicitly account for the effects of unobserved factors, but the current approach does not do that.

3. KEY CONCEPTS AND HISTORICAL CONTRIBUTIONS

In an effort to address the current model's potential weaknesses, we developed several alternative models and compared their performance to that of the current model. This section discusses intermediate steps of model development. It starts with the definition of a concept that we believe to be fundamental to modeling and projecting employer contributions. It then documents aggregate contributions in recent years. It turns out that contributions vary substantially from year to year, which poses a challenge to model evaluation. For example, actual contributions in a certain year may be much higher or lower than projected by a model that aims to match an average level of contributions. We therefore developed metrics to evaluate model performance that compare projections to actual contributions on the basis of their correlation rather than absolute levels.

Minimum Required Cash Contribution

The Minimum Required Contribution (MRC) plays a central role in the current projection approach. For poorly funded plans, the projected contribution is equal to the MRC; for other plans, it is a weighted average of the MRC and another metric. Instead of contributing cash, a sponsor may apply some or all of its available credit balance toward the MRC. The current

---

[3] "SE Contribution Policy Assumption for PIMS, FY 2019 Projections Report." May 18, 2020.
[4] Michael Brien and Constantijn Panis. 2011. "The Determinants of Defined Benefit Pension Plan Funding." Report for the U.S. Department of Labor, Employee Benefits Security Administration.
[5] These concepts relate closely to so-called Contribution Indices developed by the Society of Actuaries; see "Contribution Indices: U.S. Single Employer Pension Plans," May 2016, available at https://www.soa.org/globalassets/assets/files/research/projects/research-2016-contrib-indices.pdf.

projection approach assumes that sponsors use 90% of the available credit balance and contribute the remainder in cash.

The application of a credit balance does not affect a plan's assets, liabilities, or cash flows. It is an accounting maneuver without implications for the potential liability that PBGC faces. From the perspective of PBGC, the primary metric of interest is the amount of cash that a plan sponsor contributes. We therefore recommend that the modeling approach focus on cash contributions only, without concern over how much of the available credit balances a plan applies. Indeed, as explained next, the model needs to project cash contributions only, and any use of credit balances follows logically.

With a focus on cash contributions, we introduce the concept of Minimum Required *Cash* Contribution (MRCC). The MRCC is the MRC minus the available credit balance, but never less than $0.

$$\text{MRCC} = \max(0, \text{MRC} - \text{Credit Balance})$$

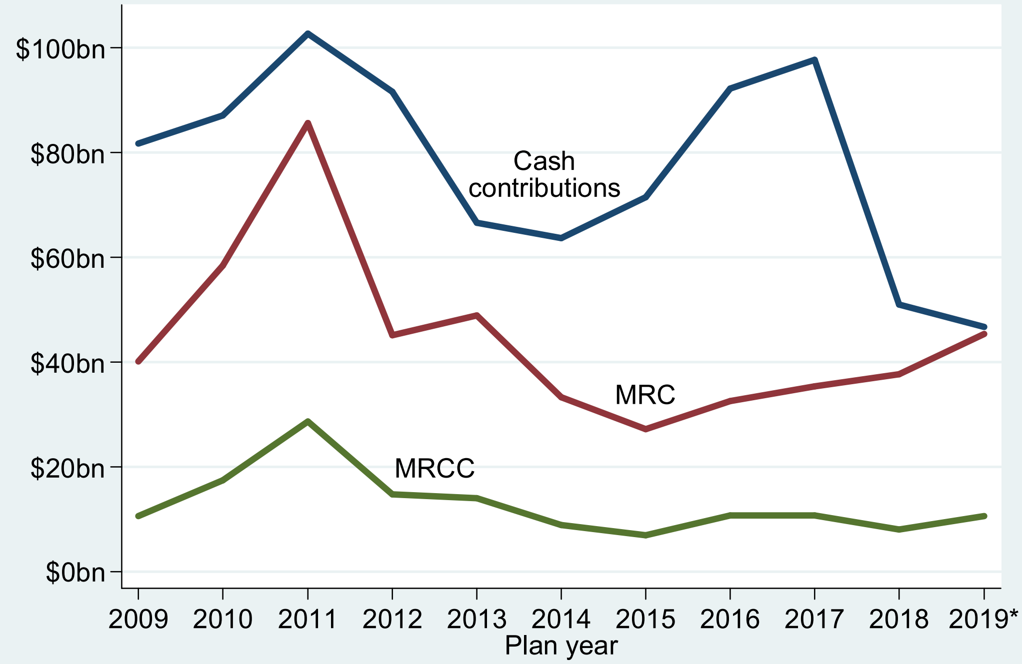
Modeling and projecting cash contributions eliminates the need for an assumption regarding application of credit balances, provided that the cash contribution is equal to or greater than the MRCC. Should the projected cash contribution be less than the MRC, the shortfall is drawn from the credit balance which, by definition, is available.

Historical Contributions

Figure 1 shows aggregate annual MRCC, MRC, and actual cash contributions to single-employer defined benefit plans for plan years 2009 through 2019, as based on Schedule SB of Form 5500 filings.[6] Aggregate annual cash contributions substantially exceeded the MRCC in all years. The MRCC is also smaller than the MRC in all years because of widely available credit balances. Total cash contributions in plan years 2016 and 2017 far exceeded those in 2018. This may reflect an acceleration of plan contributions in order to shift taxable income from corporate fiscal year 2017 to 2018, when the federal corporate income tax rate was reduced. The MRCC decreased between 2017 and 2018 even though the MRC increased, presumably because many plans accumulated a credit balance through their excess contributions in 2017.

[6] The analysis file is based on Form 5500 filings of single-employer defined benefit plans for which a matching PBGC Comprehensive Premium Filing was located. Contributions are based on Schedule SB, lines 19c and 37, the MRC on line 34, and the MRCC on lines 34 and 35. The data were extracted on January 4, 2021.

Figure 1. Aggregate Annual Minimum Required and Actual Cash Contributions, by Plan Year (2009-2019)



Source: Form 5500 filings
* The data for plan year 2019 are likely incomplete.

Table 2 shows the data on which Figure 1 is based. The number of plans in the analysis data is lower in 2019 than in earlier years, suggesting that publicly available Form 5500 filings are incomplete for 2019.

Table 2. Aggregate Annual Contributions, by Plan Year (2009-2019)

Plan Year	# Plans	Minimum Required Cash Contributions ($bn)	Minimum Required Contributions ($bn)	Actual Employer Cash Contributions ($bn)
2009	24,899	10.6	40.1	81.8
2010	24,482	17.5	58.4	87.1
2011	23,714	28.7	85.7	102.8
2012	23,387	14.8	45.1	91.6
2013	23,595	14.0	48.9	66.6
2014	24,244	8.9	33.3	63.7
2015	24,568	7.0	27.2	71.5
2016	24,916	10.8	32.6	92.2
2017	24,994	10.8	35.4	97.7
2018	24,509	8.0	37.7	51.0
2019*	20,082	10.6	45.4	46.8

Source: Form 5500 filings, Schedule SB.
Plan year 2019 may be incomplete.

The large year-over-year fluctuations of cash contributions poses a challenge to model development and evaluation. A common approach would be to develop a model based on data through 2017, apply the parameter estimates to project 2018 contributions, and compare actual to projected 2018 contributions to evaluate the model's performance. However, the model would most likely project contributions that are far greater than actual contributions because contributions in 2018 were unusually low; see Figure 1. PBGC addressed this issue by targeting an aggregate level of 2018 contributions that the model developers considered reasonable, rather than the actual level of 2018 contributions. As discussed further below, we agree with that approach, subject to additional sensitivity analyses.

Plans are legally required to contribute in cash at least the MRCC. Our modeling efforts therefore focus on the amount by which cash contributions exceed the MRCC. We refer to this outcome as the "excess contribution."

Model Evaluation Criteria

Ideally, a model of employer contributions in SE-PIMS would project values that closely approximate actual future values through such explanatory variables as asset returns, funding shortfalls, Variable Rate Premium (VRP) incentives, etc. Unfortunately, existing models inevitably leave sizeable aggregate annual fluctuations unexplained.[7] This raises the question whether to make any adjustments to the model estimates for the purpose of projecting.

PBGC provided us with a spreadsheet that applies the current model to plan year 2018 for 15,933 plans. It is our understanding that the spreadsheet was used to develop the current model. The aggregate employer contribution in 2018 for the plans in the spreadsheet was $47.8 billion and the aggregate projected value was $68.0 billion. This does not mean that the current model performs poorly: 2018 was an unusual year because of the decrease in the corporate tax rate that took effect in that year.

A model whose projections match actual contributions in 2018 would likely under-project future contributions. We therefore believe it is realistic to calibrate the projection model such that its aggregate (or per-plan average, or per-participant average) projection is equal to a long-term target. Indeed, the over-projection of PBGC's current model was intentional; the aggregate projection is a choice parameter, informed by the opinions of PBGC experts.

Consider again Figure 1 and Table 2. The average aggregate contribution in 2013–2016 was $73.5 billion and the average in 2013–2019 was $69.9 billion. PBGC's spreadsheet covered a subset of the plans in our analysis accounting for approximately 94% of employer contributions. PBGC's aggregate projection of $68.0 billion in 2018 therefore seems reasonable. That said, the target may have large implications for potential liabilities projected by SE-PIMS; see the discussion on scenario analyses below.

Because projections may be calibrated to achieve a certain target, we recognize that the absolute value of projected contributions is of less importance than the extent to which

[7] SE-PIMS and other microsimulation models are further limited in their ability to control for time-varying determinants because their future values may be unknown. Case in point is the sharp drop in contributions between 2017 and 2018, which may be attributable to a change in (time-varying) corporate tax rates.

projections correlate with actual contributions. We therefore propose to evaluate the current and alternative models based on the correlation coefficient of actual and projected contributions ("Amount Correlation"). It is calculated on 15,067 plan filings that are both in PBGC's development spreadsheet and AACG's analysis file.[8]

As explained in the next section, our alternative specification considers the ratio of excess contributions to VBL as the outcome of interest. We therefore propose to further evaluate the performance of models based on the correlation of (1) the ratio of actual excess contributions to VBL and (2) the ratio of projected excess contributions to VBL ("Ratio Correlation").

The Ratio Correlation and Amount Correlation can range from -1 to 1, where 1 denotes perfect concordance and 0 denotes no correlation. Negative values would suggest inverse projections, that is, increasing when the actual values decrease and vice versa.

Applied to the current model of employer contributions, the Ratio Correlation is 0.2164 and the Amount Correlation is 0.5277 (see Table 3). These values form the benchmarks against which alternative model specifications may be evaluated.

Table 3. Model Evaluation Criteria for the Current Model of Employer Contributions

	Current Model
Ratio Correlation	0.2164
Amount Correlation	0.5277

4. ALTERNATIVE MODELS OF EMPLOYER CONTRIBUTIONS

Type of Model

We explored several alternative models of a statistical or econometric nature. The ultimate outcome of interest is the amount that a plan sponsor contributed in cash to its plan in a certain year. For legal reasons, the contribution is greater than or equal to the MRCC.[9] An intermediate outcome of interest is therefore the difference between contributions and the MRCC. That amount is often zero. When it is not zero, its magnitude varies greatly across plans, from $1 to billions of dollars in some cases.

---

[8] The AACG analysis file consists of plan year 2009–2019 Form 5500 filings of single-employer defined benefit plans for which a matching Premium Filing was located. It excludes final filings and filings with zero participants, negative credit balances, funded ratios below 10% or above 400%, negative or zero assets, liabilities under $10,000, or missing assets or liabilities. The intersection of PBGC spreadsheet and our analysis file consists of 15,067 plans which account for more than 99% of actual contributions in PBGC's spreadsheet.

[9] In practice, some plan sponsors make a contribution that falls short of their MRCC. In some cases, they restore missed contributions in later years and manage to achieve funding similar to what it would have been if they had contributed at least the MRCC. In other cases, the shortfall precedes bankruptcy of the plan sponsor. The current implementation of SE-PIMS assumes that sponsors will contribute at least the legal minimum and erases the last year of projected contributions in the case of a bankruptcy (*PIMS System Description*, Section 4.2.8). We consider those assumptions sensible and recommend no change.

The estimation procedure of econometric models generally minimizes or maximizes some metric. For example, Ordinary Least Squares (OLS) estimation minimizes the sum of squared residuals, where a residual is the difference between the actual contribution and the model-predicted contribution for a certain plan in a certain year. Because the minimization focuses on *squared* residuals, large residuals carry more weight than small residuals. In practice, this means that plans with large contributions have far greater influence on model estimates than plans with small contributions. It may be acceptable, desirable even, that large plans carry more weight because they account for a large share of PBGC's potential liability. However, it may be undesirable that their influence increases quadratically. For that reason, econometric models tend to perform best when the outcomes are of the same order of magnitude. In contrast, excess contributions vary very widely.

A potential approach would be to model the natural logarithm of excess contributions, rather than excess contributions themselves. Non-zero excess contributions in our analysis data ranged from $1 to about $8 billion; the corresponding logarithm ranges from 0 to 22.8. A log-based model is thus less susceptible to outsized influence of large plans. However, a large share of plans contributed the MRCC (26.3%) or up to 101% of the MRCC (34.1%). The model could consist of two equations. The first would address the decision to contribute (very close to) the minimum versus more than the minimum. Conditional on making an excess contribution, the second equation would explain the log-amount. We explored such a model, but found it lacking in its capability to replicate actual contribution behavior.

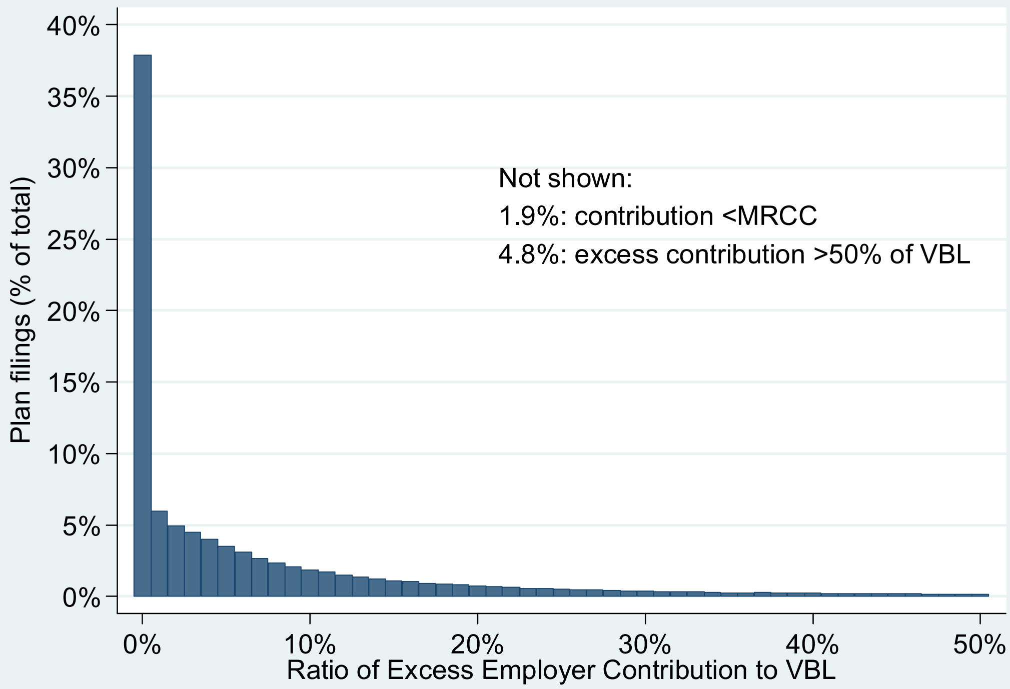
An alternative potential approach would be to model the ratio of excess contributions to some measure of plan size. We explored per-participant excess contributions, but even that outcome has a wide range. Instead, we opted for the ratio of excess contributions to the vested benefits liability (VBL) for the start of the plan reporting period:

$$y_{it} = \frac{C_{it} - MRCC_{it}}{VBL_{it}}$$

where C_{it}, $MRCC_{it}$, and VBL_{it} denote the contribution, MRCC, and VBL, respectively, for plan *i* in year t, and y_{it} is the intermediate outcome of interest. The VBL is measured at the start of the reporting period, as reported on Premium Filings.[10] Figure 2 shows its distribution in our pooled 2009–2019 analysis data, which exclude final filings and filings with zero participants, negative credit balances, funded ratios below 10% or above 400%, negative or zero assets, liabilities under $10,000, or missing assets or liabilities.

[10] VBL is often missing on Premium Filings, such as for plans that are exempt from Variable Rate Premiums (VRPs). We imputed missing values as 125% of the VBL reported on line 3d(2) of Schedule SB of the Form 5500.

Figure 2. Distribution of the Ratio of Excess Contributions to Vested Benefits Liability



Source: 2009-2019 Form 5500, Schedule SB, and Premium Filings.

The tall bar at 0% represents 37.9% of filings that reported contributions approximately equal to the MRCC. The distribution excludes 1.9% of plan filings that reported contributing less than the MRCC; see footnote 9 (page 9). It also does not show 4.8% of plan filings with excess contributions that were more than 50% of VBL. These plans were generally small plans with very low VBL. Weighted by VBL, the fraction would round to 0.0% (not shown).

The remainder of the distribution resembles one side of a bell curve, i.e., the distribution approximates a left-censored normal distribution. A commonly used model for such outcomes is the Tobit model:[11]

$$y_{it} = \max(0, \beta' x_{it} + \varepsilon_{it})$$

where β is a vector of parameters, x_{it} is a vector of explanatory variables for plan *i* at time t, and ε_{it} is a normally distributed residual. The model is readily estimated using standard statistical software packages.

Projections based on a Tobit model are calculated as follows. Denote the parameter estimates by vector $\hat{\beta}$. The predicted value of the ratio of excess contributions to VBL is $\max\left(0, \hat{\beta}' x_{it}\right)$, and the predicted contribution is $\max\left(0, \hat{\beta}' x_{it}\right) VBL_{it} + MRCC_{it}$. As explained above, the intercept estimate may be calibrated such that the aggregate predicted

[11] James Tobin. 1958. "Estimation of Relationships for Limited Dependent Variables." *Econometrica* 26(1): 24–36.

contributions match a target. In our calculations, we targeted the same aggregate 2018 contributions as PBGC did.

Model Estimates and Performance

We explored a model based on the target amounts that are central to the current model:

- MRC: legally required minimum contribution amount.
- AFTAP80: contribution amount that would lift the AFTAP to 80%.
- UVBL: contribution amount that would erase the unfunded vested benefits liability.
- TNC: contribution amount that would equal the target normal cost (amount by which liabilities grew in the current year).
- MAXP3: contribution amount that would restore the VBL funded percentage to its maximum over the past three years

We calculated these amounts for all plans in the analysis file and, mirroring the model's outcome, converted them into ratios of their excess over MRCC to VBL. We omitted MRC because the MRC may contain a non-cash component and because our model considers the excess of contributions over the MRCC. Table 4 shows model parameter estimates.

Table 4. Tobit Estimates of the Ratio of Excess Contributions to VBL (1)

	(1)	(2)
Max(0, (AFTAP80-MRCC)/VBL)	-0.0317 **	
	(0.0157)	
Max(0, (UVBL-MRCC)/VBL)	-0.0265 ***	
	(0.0040)	
Max(0, (TNC-MRCC)/VBL)	1.1285 ***	1.1315 ***
	(0.0017)	(0.0017)
Max(0, (MAXP3-MRCC)/VBL)	-0.0037 ***	
	(0.0011)	
Intercept	-0.0057 ***	-0.0086 ***
	(0.0007)	(0.0006)
Std. Dev. of Residual	0.2493 ***	0.2494 ***
	(0.0004)	(0.0004)
Observations	228,678	228,678
— of which left-censored	60,217	60,217
Ratio Correlation	0.6434	0.6431
Amount Correlation	0.5236	0.5195

Standard errors in parentheses.
Significance: *=10%, **=5%, ***=1%.

The first column shows that transformations of AFTAP80, UVBL, and MAXP3 have negative estimated effects. In other words, higher values of AFTAP80, UVBL, and MAXP3 appear to reduce employer contributions, which is contrary to our expectations.[12] The effect of TNC is

[12] The parallel with the current projection model is not perfect. In particular, the current model uses AFTAP80 for plans that are less than 80% funded only, and it uses UVBL, TNC, and MAXP3 for plans that are more than 80% funded only. In contrast, the specification in

positive and strongly significant. Its parameter estimate is about 1.13. This means that if TNC were to increase by $1, the predicted employer contribution would increase by $1.13.

The last two rows of Table 4 display the two model evaluation metrics.[13] The Ratio Correlation is 0.6434, which is better than the corresponding statistic based on the current model (0.2164). The Amount Correlation is 0.5236, which is similar to that of the current model (0.5277).

The second column of Table 4 shows estimates of a model that controls for transformed TNC only. This simple specification performs well, with a Ratio Correlation of 0.6431 and an Amount Correlation of 0.5195. In other words, even by itself, TNC appears to be extraordinarily promising to explain employer contributions.[14]

We explored numerous other factors that may explain employer contributions; see Table 5. The first column shows exploratory estimates; the second column shows our preferred specification. The definitions and estimated effects of potential determinants are as follows.

- *Cash balance plan*. Employers contributed more to plans with a cash balance feature than to other plans. We are unaware of any plausible theoretical foundation for this finding and omitted it from the preferred specification in the second column.
- *Lump-sum window*. Contributions to plans that offered a lump-sum window were not significantly different from contributions to other plans. This is consistent with lump-sum payments being approximately equal to the liability that they transfer out of the plan.
- *Annuity buy-out*. Plans that purchased a group annuity with the objective of transferring benefit obligations to an external party tended to experience an additional cash infusion. This may be related to premiums over the associated liability that the buyers of annuities tend to charge.[15] SE-PIMS does not currently project annuity buy-outs and the variable is therefore omitted from the preferred specification.

Table 4 applies all explanatory variables equally to all plans. We explored interactions with funded status, but the estimated effects of AFTAP80, UVBL, and MAXP3 were negative throughout.

[13] Denote the parameter estimates by vector $\hat{\beta}$ (first five rows of Table 4). The model evaluation criteria were calculated by first calculating (1) the predicted values of the ratio of excess contributions to VBL, $\max\left(0, \hat{\beta}' x_{it}\right)$, and (2) the predicted contributions, $\max\left(0, \hat{\beta}' x_{it}\right) VBL_{it} + MRCC_{it}$. We subsequently calibrated the intercept estimate such that the aggregate predicted contributions matched PBGC's target. The correlations are based on the same 15,067 plan filings that were used to evaluate the current model.

[14] Based on this finding, we explored an even simpler model in which the projected value is equal to max(MRCC, TNC), where TNC is scaled to ensure that the aggregate projection matches PBGC's aggregate projection. The resulting Ratio Correlation was 0.6361 and the Amount Correlation 0.5718.

[15] Annuity buy-outs tend to cost roughly 110% of the liability that they transfer. See "ERISA Industry Council Written Testimony of Evan Inglis, FSA, CFA." June 5, 2013. Available at https://www.dol.gov/sites/dolgov/files/EBSA/about-ebsa/about-us/erisa-advisory-council/2013-private-sector-pension-derisking-and-participant-protections-inglis-06-05.pdf.

Table 5. Tobit Estimates of the Ratio of Excess Contributions to VBL (2)

	Explore	Preferred
Cash balance plan	0.0256 ***	
	(0.0012)	
Lump-sum window	-0.0055	
	(0.0049)	
Annuity buy-out	0.0223 ***	
	(0.0053)	
Marginal Variable Rate Premium	0.2368 ***	0.1017 *
	(0.0555)	(0.0543)
Funded <75%	-0.0270 ***	
	(0.0024)	
Funded 75%-85%	0.0065 ***	
	(0.0019)	
Funded 85%-95%	-0.0022	
	(0.0017)	
Funded 95%-110%	-0.0348 ***	
	(0.0013)	
max(0, (TNC-MRCC)/VBL)	1.0783 ***	1.0984 ***
	(0.0017)	(0.0017)
S&P 500 Return (lagged)	-0.0248 ***	-0.0212 ***
	(0.0031)	(0.0031)
Log(Participants)	-0.0112 ***	-0.0111 ***
	(0.0002)	(0.0002)
Intercept	0.0425 ***	0.0376 ***
	(0.0013)	(0.0011)
Std. Dev. of Residual	0.2469 ***	0.2477 ***
	(0.0004)	(0.0004)
Observations	228,678	228,678
— of which left-censored	60,217	60,217
Ratio Correlation	0.6562	0.6521
Amount Correlation	0.5490	0.6199

Standard errors in parentheses.
Significance: *=10%, **=5%, ***=1%.

- *Marginal VRP rate*. The Variable Rate Premium (VRP) rate increased from 0.9% of the UVBL in plan years 2009–2013 to 4.3% in 2019. The marginal VRP rate is defined as the VRP rate, but zero if the plan did not pay any VRP (as determined from Premium Filings) because it was fully funded or exempt from paying VRPs. The marginal VRP rate is also zero if the plan's VRP is capped at its maximum because a small reduction of the UVBL would not reduce the VRP. As expected, the marginal VRP rate is positively related to employer contributions. A coefficient of 0.2368 means that if the VRP were to increase by one percentage point (0.01), contributions would be expected to increase by approximately 0.2368 x 0.01 = 0.2368% of VBL. The magnitude of the effect is sensitive to other included factors that correlate with funded status. For example, an additional control for plans being at the VRP cap would have a negative effect (as expected, because being at the cap mitigates the incentive to reduce underfunding), but the effect of the marginal VRP rate would not be statistically significant (not shown).
- *Funded <75%, 75%–85%, 85%–95%, and 95%–110%*. The first column includes indicator variables for funded level, as based on line 15 of Schedule SB (Adjusted Funding Target Achievement Percentage). The reference category is 110% or better

funded. The estimated pattern is difficult to interpret because it is not monotonic in funding level. Even without controlling for the marginal VRP rate, the effect of funded status would not be monotonic (not shown). A single indicator for funding below 80% was estimated to have a negative effect, which is inconsistent with an incentive to reach 80% funding (not shown). Also, if the funded level indicators were based on funding level reported on Premium Filings, the pattern would not be monotonic (not shown). The indicators are omitted from the preferred specification, but see below for a discussion on the role of funding level, even without funding indicator variables.

- *Max(0, (TNC-MRCC)/VBL)*. Consistent with estimates in Table 4, the effect of (a transformation of) TNC is approximately one-for-one and strongly significant.
- *S&P 500 Return (lagged)*. This variable is the one-year lagged rate of total return (including dividends) of the companies in the S&P 500 index. Its effect is negative and significant, suggesting that favorable rates of return on plan assets are a substitute for employer contributions. An increase of 10 percentage points (0.10) in the rate of return translates into reduced contributions of approximately -0.0248 x 0.10 = 0.248% of VBL.[16]
- *Log(Participants)*. All else equal, sponsors of plans with more participants tended to contribute less. Controlling for the natural logarithm of plan participants resulted in a better model fit than controlling for indicator variables for plan size categories (not shown). A piecewise-linear specification in the natural logarithm of plan participants performed only slightly better than a linear specification (not shown).

The preferred model in Table 5 resulted in a Ratio Correlation of 0.6521 and an Amount Correlation of 0.6199. On both metrics, the model outperforms the current model.

We attempted to estimate models based on only the 488 plans that are included in the 2019 iteration of SE-PIMS. For most of those plans, corporate financial information was available from Compustat. Among variables of interest was the excess, if any, of the marginal VRP rate over the sponsor's average interest rate on corporate debt. However, there was no statistically significant support for the hypothesis that companies that can borrow at less than the marginal VRP rate took the opportunity to reduce their UVBL. Separately, corporate financial health, as measured by the ratio of cash flow to corporate assets, appeared to be correlated with higher contributions. The results were sensitive to specification changes, possibly because of the small sample size.

The Role of Funding Level

It may appear counterintuitive that the preferred model specification does not explicitly control for funding level. However, funding level has important and direct consequences for projected employer contributions in the preferred model. Recall that the model's intermediate outcome is the ratio of excess contributions to VBL:

---

[16] The role of the rate of return on bonds is more involved. The rate of return on bonds affects both assets (insofar invested in bonds) and liabilities because the discount rate for valuing liabilities moves in tandem with the rate of return on bonds. A rising bond return lifts assets and lowers liabilities, thus improving the funded ratio. Much of the effect operates through the MRCC because excess assets, if any, increase and underfunding amortization, if any, decreases. We tested empirically for any remaining effect and found it to be positive (suggesting that higher rates of returns on bonds imply higher employer contributions), which may be counterintuitive. Instead, we opted to let the effect of bond returns operate through the MRCC.

$$\frac{C_{it} - MRCC_{it}}{VBL_{it}} = \max(0, \beta' x_{it} + \varepsilon_{it})$$

Denoting parameter estimates by $\hat{\beta}$ and ignoring the stochastic component (ε_{it}), it follows that projected contributions are:

$$MRCC_{it} + \max\left(0, \hat{\beta}' x_{it}\right) VBL_{it}$$

For underfunded plans, credit balances are often small or zero, so that MRCC equals the sum of TNC and amortizations of prior funding or contribution deficits. The projected contribution includes those components at a minimum. A severely underfunded plan faces larger amortizations than a modestly underfunded plan, and those differences directly affect the projected contribution. In addition to MRCC, the projection may include an excess contribution of $\max\left(0, \hat{\beta}' x_{it}\right)$ times the VBL. The effect of TNC is to raise the projected contribution dollar-for-dollar through the MRCC; it drops out of the regression because MRCC>TNC and therefore $\max\,(TNC_{it} - MRCC_{it}, 0)/VBL_{it}$ is zero. The marginal VRP rate and the recent rate of return on equity may incentivize employers to make an excess contribution.

For overfunded plans, MRCC is often zero because of excess assets and credit balances. The projected contribution is then $\max\left(0, \hat{\beta}' x_{it}\right)$ times the VBL. The marginal VRP rate has no effect on projected contributions because it is zero for overfunded plans. TNC affects the projected contribution approximately dollar-for-dollar because the estimated coefficient on $\max\,(TNC_{it} - MRCC_{it}, 0)/VBL_{it}$, 1.0984, is close to one. The recent rate of return on equity may prompt a further adjustment of the projected contribution.

Finally, consider plans that are frozen to new accruals and for which TNC is zero. If underfunded, the projected contribution is at least equal to amortized funding and contribution deficits, and employers are incentivized by the marginal VRP rate to make additional contributions. If overfunded, contribution decisions are driven by the recent return on equity.

In all cases, plan size also affects any excess contributions, presumably because of plan administration efficiencies.

Discussion

The current model is built around five target amounts that represent meaningful concepts to plan sponsors. However, the contributions that the current model projects need not be equal to those target amounts but instead, for example, 15% of UVBL, 130% of TNC, or 25% of recent funding erosion, depending on funded level or other factors. While the target amounts are meaningful, the contribution amounts are less easy to interpret.

A relatively straightforward statistical model indicated that the TNC is indeed a strong predictor of employer contributions. Conditional on TNC (and MRCC), the other concepts did not have the expected relationship to contributions.

Our preferred model specification controls for TNC, the marginal VRP rate, the rate of total return on equity, and the number of plan participants. With these four variables, the model performed better than the current model; see Table 6.

Table 6. Summary of Model Evaluation

	Current Model	Preferred Model
Ratio Correlation	0.2164	0.6521
Amount Correlation	0.5277	0.6199

The preferred model directly controls for the marginal VRP rate, which allows SE-PIMS to support what-if scenario analyses of potential future changes in the VRP rate or its applicability to certain types of plans. It further controls directly for the rate of return on stocks, which affects the current model through its implications for funded level and amounts required to restore prior funded levels.

In neither the current nor the preferred model of employer contributions does corporate financial performance play a role, despite evidence of a link in historical data. Corporate financial performance is available only for plan sponsors with publicly available financial information, i.e., for large public companies, such as most of those in the SE-PIMS sample. Filings from plans in SE-PIMS can shed light on the role of corporate financial performance, but their small sample size implies that estimates of other drivers of contributions are less precise than those based on the universe of plans. Separately, corporate financial performance varies over time. SE-PIMS contains a module to project their future values, but those projections are subject to much uncertainty. We favor a model that does not control for corporate financial performance but instead absorbs it in its residual.

Recall that the preferred model's predicted contribution is $\max\left(0, \hat{\beta}' x_{it}\right) VBL_{it} + MRCC_{it}$. If desired, the model supports stochastic projections by adding a random draw of the model's normally distributed residual: $\max\left(0, \hat{\beta}' x_{it} + \varepsilon_{it}\right) VBL_{it} + MRCC_{it}$. See Table 5 for an estimate of the standard deviation of ε_{it}.

5. RECOMMENDATIONS

Model Specification

While the current model has intuitive appeal because of its meaningful target amounts, its implementation loosens the connection to those targets and is complex. A relatively straightforward statistical model with just one equation and four explanatory variables generates projections that correlate better with actual contributions than the current model. We recommend that PBGC consider replacing the current model.

Our preferred model assumes that plan sponsors contribute at least the Minimum Required Cash Contribution in cash. This assumption would replace the current model's assumption that sponsors contribute at least the Minimum Required Contribution by using 90% of their credit balances and contributing the remainder in cash. Neither assumption is fully consistent with historical data because a small fraction of plans have received less than the required minimum. SE-PIMS would slightly over-project contributions for such plans, at least insofar the shortfalls are not subsequently made up. However, unremedied shortfalls generally foreshadow a bankruptcy, and SE-PIMS reverses the last year of contributions when it projects a bankruptcy (*PIMS System Description*, Section 4.2.8). We recommend no change to that aspect of bankruptcy modeling.

Sensitivity Analysis

A fundamental difficulty with both the current model and any replacement is establishing the aggregate level of contributions in baseline projections. (The same issue exists with the per-participant average contribution or similar concepts.) Aggregate contributions have fluctuated substantially in recent years, and changes in the way calendar time is captured in statistical models can generate a range of aggregate projections. PBGC addressed this issue by targeting a certain aggregate level of projected contributions, even though the model developers were presumably aware that that target differed greatly from actual contributions. In our model development, we adopted the same approach as PBGC.

The value of the aggregate contribution target used in SE-PIMS can have a profound effect on the output of SE-PIMS. A higher target would project higher contributions, better funded plans, and lower claims in the event of bankruptcies; a lower target would increase projected claims. In light of the uncertainty about targeted aggregate contributions, we recommend PBGC conduct a sensitivity analysis.

Specifically, we recommend that experts develop a range of plausible targets for aggregate contributions and select low, medium, and high values for high-cost, baseline, and low-cost scenarios, respectively. SE-PIMS would run for those scenarios to determine the sensitivity of PBGC's financial outlook to the level of aggregate contributions. If the sensitivity is high, an implementation with periodic recalibration would be warranted.

DISCLAIMER

The views, opinions, and/or findings contained in this report should not be construed as an official Government position, policy or decision, unless so designated by other documentation issued by the appropriate governmental authority.

We call your attention to the possibility that other professionals may perform procedures concerning the same information or data and reach different findings than Advanced Analytical Consulting Group, Inc. (AACG) for a variety of reasons, including the possibilities that additional or different information or data might be provided to them that was not provided to AACG, that they might perform different procedures than did AACG, or that professional judgments concerning complex, unusual, or poorly documented matters may differ.

This document contains general information only. AACG is not, by means of this document, rendering business, financial, investment, or other professional advice or services. This document is not a substitute for such professional advice or services, nor should it be used as a basis for any decision or action. Before making any decision or taking any action, a qualified professional adviser should be consulted. AACG, its affiliates, or related entities shall not be responsible for any loss sustained by any person who relies on this publication.

This document is the Final Report on SE Contribution Policy, Part 3 of Deliverable 1 under Contract 16PBGC20C0015 (PIMS Peer Review — Single Employer Contribution Policy and Risk Transfer Analysis and Multi-Employer Active Population Analysis).