Congressional Budget Office

November 2, 2016

# Projection and Alignment Methods for Static Microsimulation Models

Association for Public Policy Analysis and Management
2016 Pre-Conference Workshop

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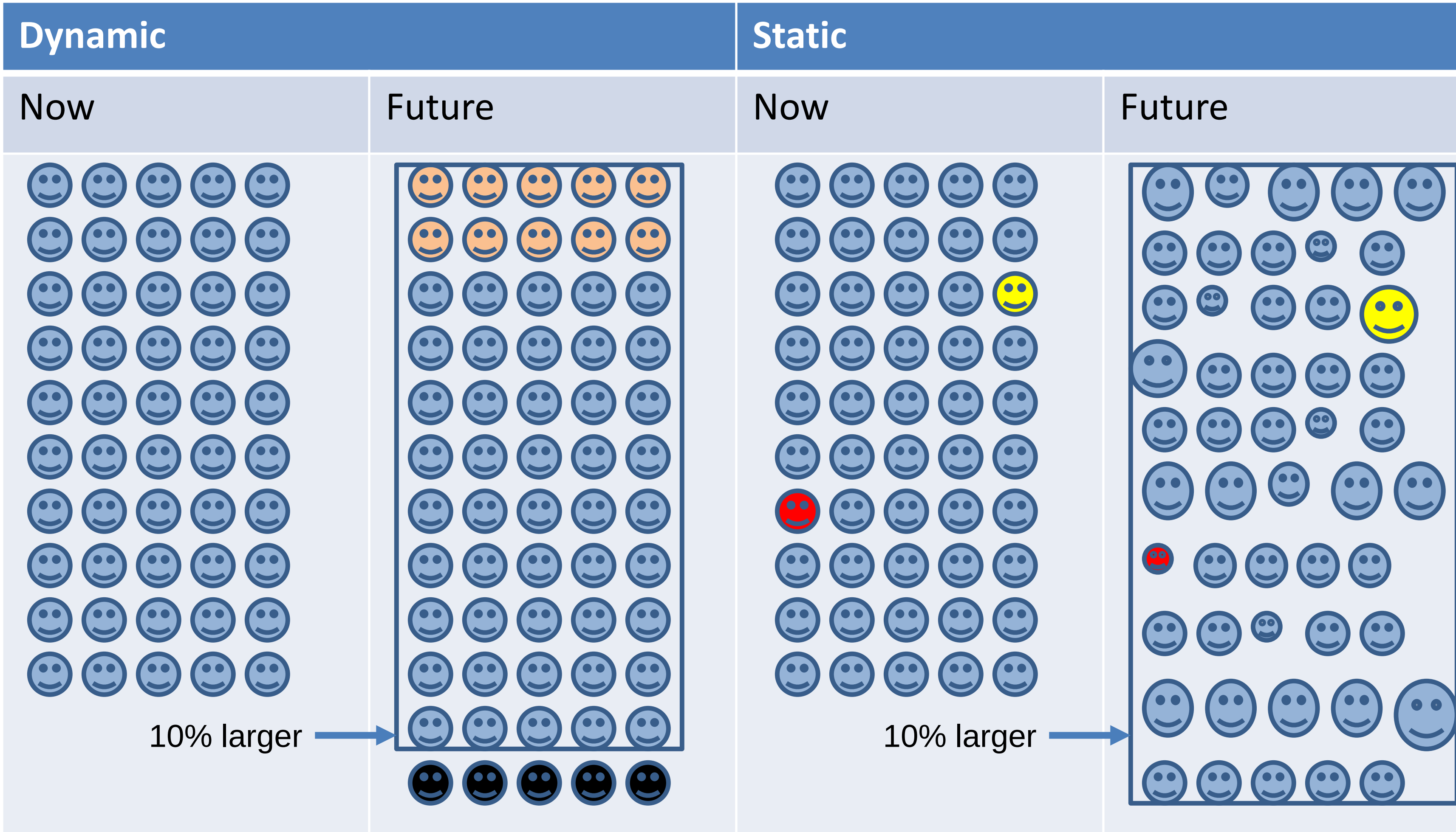
As developmental work for analysis for the Congress, the information in this presentation is preliminary and is being circulated to stimulate discussion and critical comment.

# Microsimulation Models




$n_1 > n_0$

$n_1 = n_0$

# A Quick Outline of This Presentation

1) CBO’s Individual Income Tax Model
   - Overview
   - Current Projection and Alignment Methodology

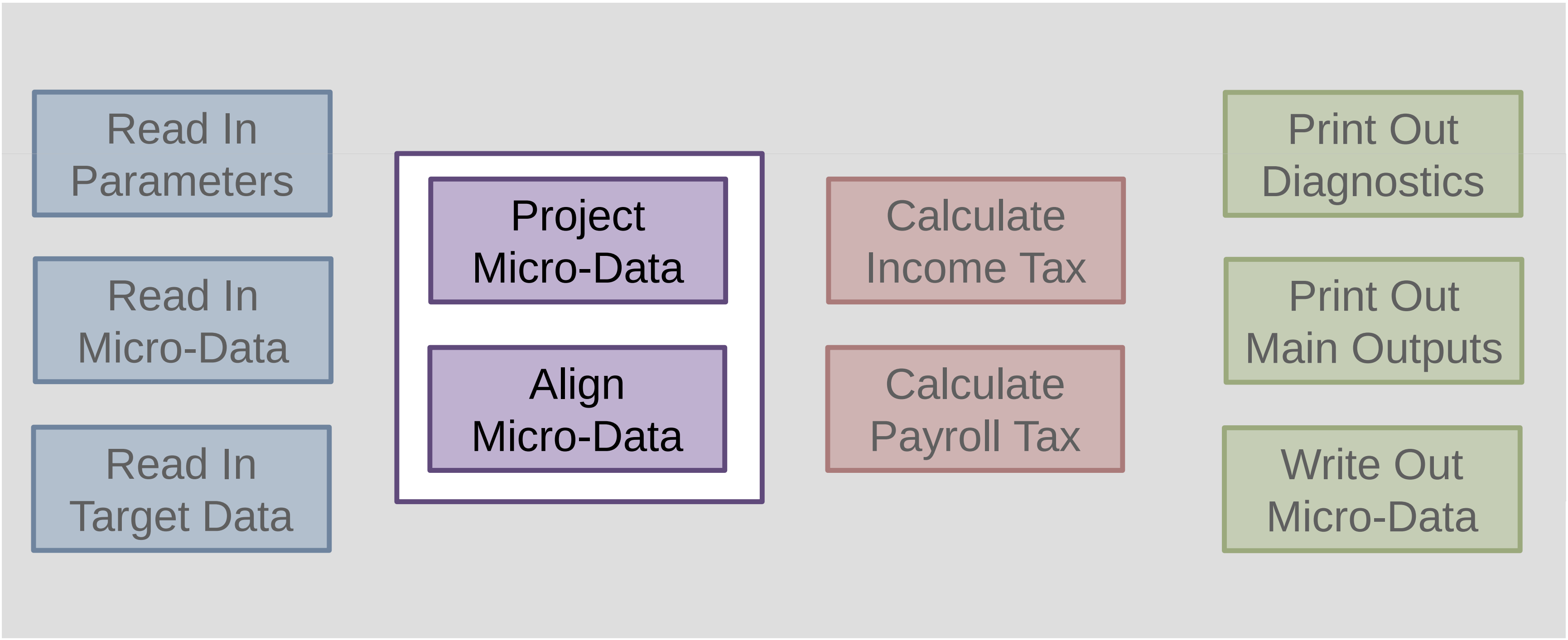
2) How Other Static Microsimulation Models Project and Align Their Data

3) Criteria for New Projection and Alignment Methodology

# 1) CBO's Individual Income Tax Model: Overview

- Began in mid-1980s; models and projects the effects of major tax reforms
- Written in Fortran
- Uses data from the IRS's Statistics of Income (SOI) and the Census Bureau's Current Population Survey (CPS)
- Serves as the foundation for multiple CBO products:
  - 10-year baseline projections
  - Distribution of household income and federal taxes (retrospective)
  - Calculation of effective marginal tax rates
  - Analyses of labor supply responses to tax law changes
  - Long-term revenue projections

# 1) CBO's Individual Income Tax Model: Overview



# 1) CBO’s Individual Income Tax Model: Current Projection and Alignment Approach

## Sequential

1 — 2 — 3 — 4 — 5

Population

**Targets:** Annual population forecasts by age, sex, and marital status from CBO’s long-term analysis model

**Application:** Multiplicative weight adjustments based on *growth* in targets

**Two Problems:**

1) Unit of analysis is tax unit, not individual
    - Married couple gets simple average of two individual growth rates

2) Kids/dependents not explicitly targeted

# 1) CBO's Individual Income Tax Model: Current Projection and Alignment Approach

## Sequential

1 → 2 — 3 — 4 — 5

Population Employment

**Targets:** Annual employment forecasts from CBO's Macroeconomic Analysis Division

**Application:** Offsetting weight adjustments

$$adj\_wgt_{it}^{w} = wgt_{it}^{w} * \left(\frac{Target_t^{w}}{\sum wgt_{it}^{w}}\right)$$

Multiplicative weight adjustment to hit aggregate employment target

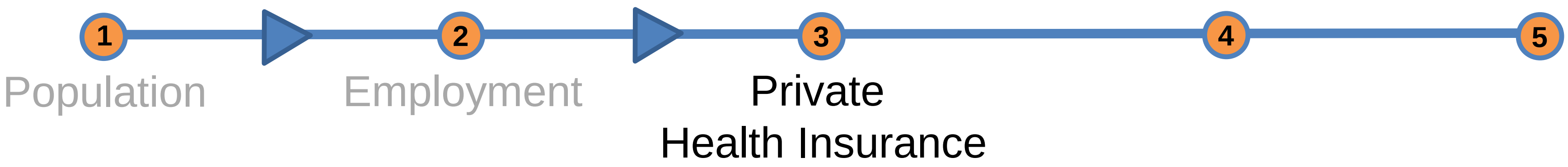
$$adj\_wgt_{ijt}^{n} = wgt_{ijt}^{n} * \left\{1 - \left[\left(\frac{Target_t^{w}}{\sum wgt_{it}^{w}}\right) * \left(\frac{\sum wgt_{ijt}^{w}}{\sum wgt_{ijt}^{n}}\right)\right]\right\}$$

Offsetting weight adjustments for nonworkers

*where* $j = 1 \ldots 42$ *cells by marital status* (0:1), *number of dependents* (0:2), *and age groups* (1:7)

# 1) CBO's Individual Income Tax Model: Current Projection and Alignment Approach

## Sequential




**Targets:** Forecasted growth in employer-sponsored health insurance (ESI) coverage from CBO's health insurance simulation model

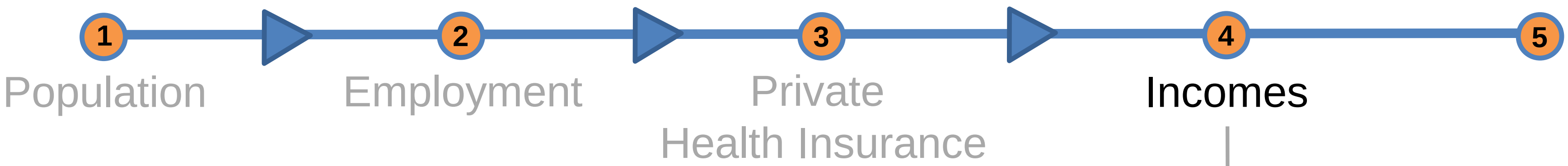
**Application:** Simulated coverage, with probabilities scaled by aggregate ESI growth rates

$$ESI\_cov_{it} = \begin{cases} 1, & if \;\; p\left(ESI\_cov_{jt_0}\right) * \left(ESI_t / ESI_{t-1}\right) > random_i \\ 0, & otherwise \end{cases}$$

*where j* = 1…48 *cells by marital status* (0:1), *number of dependents* (0:1), *earnings quartiles* (1:4), *and age groups* (1:3)

# 1) CBO's Individual Income Tax Model: Current Projection and Alignment Approach

## Sequential




**Targets:** Annual income forecasts from CBO's Macroeconomic Analysis Division

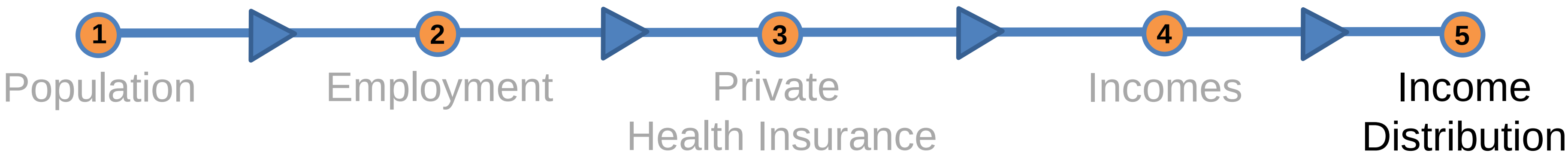
**Application:** Multiplicative scaling of ~100 income sources and tax components by *growth* in 12 projections of income sources from CBO's Macroeconomic Analysis Division

For example:

- Most income sources and tax components are grown at weighted average of growth in wages, proprietors' income, dividends, and interest income
- Short-term gain, loss, and carry-over and long-term gain, loss, and carry-over are all grown at single aggregate growth rate in net capital gains

# 1) CBO’s Individual Income Tax Model: Current Projection and Alignment Approach

Sequential




**Targets:** None; trend analysis

**Application:** Offsetting adjustments to wage and salary income growth rates

81st to 90th percentiles: Grows at average economywide growth rate

91st percentile and up: Grows faster than average

80th percentile and down: Growth rates adjusted downward to offset faster growth in top decile

(This component of CBO’s projection and alignment method is currently being reviewed and may change.)

# 2) How Other Static Microsimulation Models Project and Align Their Data

$$\hat{X}_t = \sum \boxed{x_{it}} \; w_{it}$$

Most use a two-stage technique:

1. Apply across-the-board multiplicative adjustments to $x_{it}$ to hit broad aggregate totals

# 2) How Other Static Microsimulation Models Project and Align Their Data

$$\hat{X}_t = \sum x_{it} \boxed{w_{it}}$$

Most use a two-stage technique:

1. Apply across-the-board multiplicative adjustments to $x_{it}$ to hit broad aggregate totals
2. Use a constrained optimization algorithm to adjust weights ($w_{it}$) to "fine-tune" / align the projection

# 2) How Other Static Microsimulation Models Project and Align Their Data

$$\sum x_{it} \quad w_{it}^{*} = T_{xt}$$

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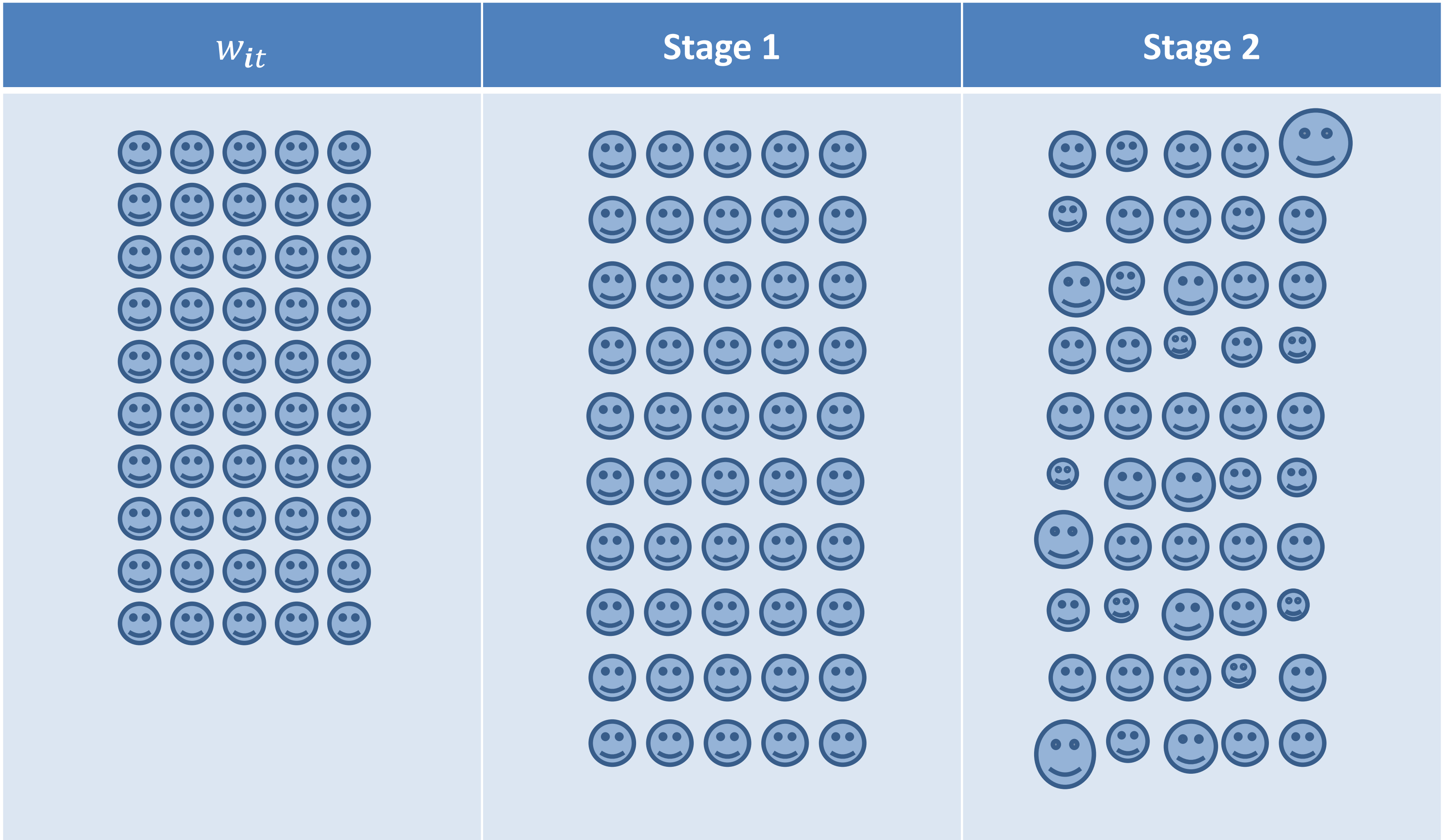
# 2) How Other Static Microsimulation Models Project and Align Their Data



# 2) How Other Static Microsimulation Models Project and Align Their Data

**One approach:**
Minimize the absolute value of the percentage change in weights ($|z_i|$) necessary to hit aggregate targets

$$\boxed{min \sum |z_i|} \quad subject\ to: \sum x_i w_i z_i = T_x - \sum x_i w_i \quad and \quad 0 \leq |z_i| \leq \delta$$

$$(where\ \delta\ is\ a\ bounding\ parameter)$$

*Operationalized by splitting $z_i$ into its positive and negative components:*

$$r_i = \begin{cases} z_i, & if\ z_i > 0 \\ 0, & otherwise \end{cases} \qquad s_i = \begin{cases} z_i, & if\ z_i < 0 \\ 0, & otherwise \end{cases} \quad \Rightarrow \quad \begin{aligned} z_i &= (r_i + s_i) \\ |z_i| &= (r_i - s_i) \end{aligned}$$

$$\boxed{min \sum (r_i - s_i)} \quad \Rightarrow \quad w_i^* = w_i(1 + r_i + s_i) \quad and \quad \sum x_i w_i^* = T_x$$

Because the objective function and the constraints are linear, the problem can be solved with a relatively straightforward linear programming algorithm, such as a simplex algorithm.

# 2) How Other Static Microsimulation Models Project and Align Their Data

**Another approach:**
Minimize the "distance" between vector of original weights ($w_i$) and new vector of weights ($w_i^*$) while hitting aggregate targets

$$min \sum \varphi(w_i, w_i^*)$$

*subject to*:

$$\sum x_i w_i^* = T_x$$

$$(can\ also\ add\ constraint\ to\ bound\ w_i^*)$$

<u>$\varphi$ can take many forms</u>:

L1 Norm: $\varphi(w_i, w_i^*) = |w_i - w_i^*|$
L2 Norm: $\varphi(w_i, w_i^*) = (w_i - w_i^*)^2$

Treasury and Joint Committee on Taxation use functional form approximately like:

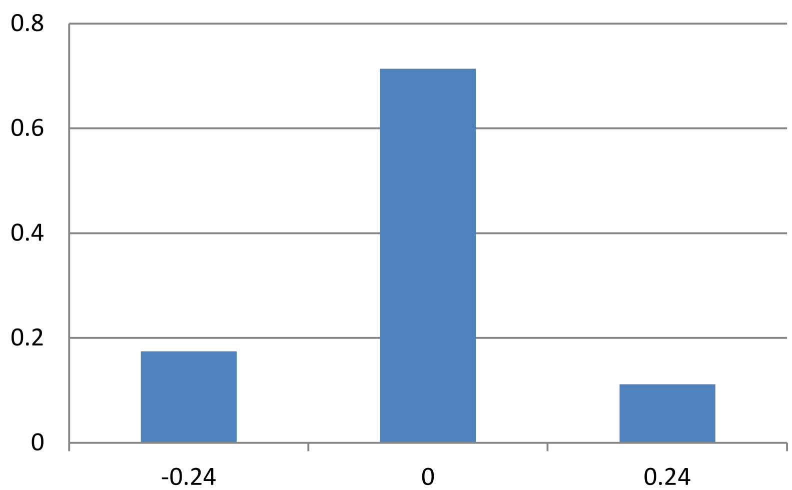
$$\varphi(w_i, w_i^*) = \left({}^{w_i^*}\!/_{w_i}\right)^4 + \left({}^{w_i^*}\!/_{w_i}\right)^{-4} - 2$$

If the objective function ($\varphi$) is nonlinear, the problem must be solved with a relatively more complex nonlinear programming algorithm.

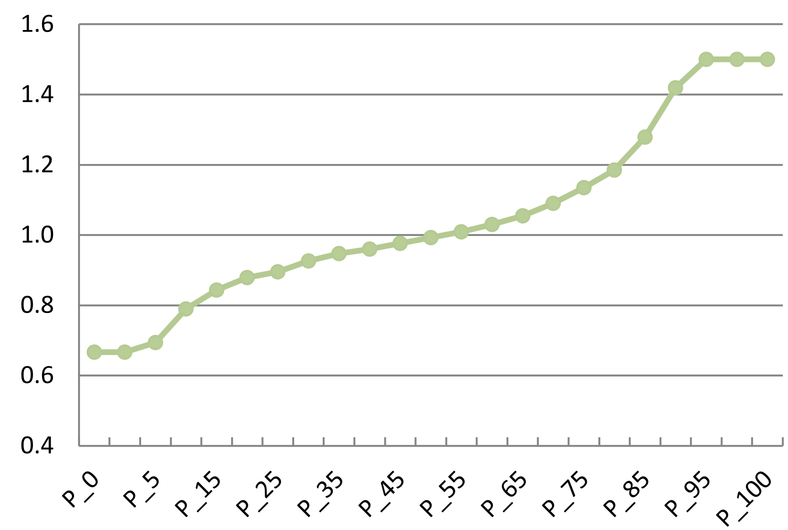
# 2) How Other Static Microsimulation Models Project and Align Their Data

**Solving 2nd stage optimization with…**

…a linear objective function and a linear programming algorithm produces a trimodal distribution of weight changes.




…a nonlinear objective function and a quadratic programming algorithm produces a smooth distribution of weight changes.




**Note**: One is not necessarily better than the other.

# 3) Criteria for New Projection and Alignment Methodology

- Keep it simple
  - Comprehension is just as important as “precision”
- Minimize aggregate and distributional effects on nontargeted variables
- Integrate with methods used for each alignment component
  - New method of labor force participation in development
  - New method to adjust income distribution under consideration
- Minimize restructuring of current model and workflow
  - Current CBO tax model incorporates projection and alignment in each model run
  - Other models project and align data in a separate module