MODULE 8

MULTILEVEL MEDIATION

OUTLINE

1. Mediation Overview
2. 1–1–1 Model With Random Intercepts
3. 1–1–1 Model With Random Slopes
4. Moderation on the α or β paths

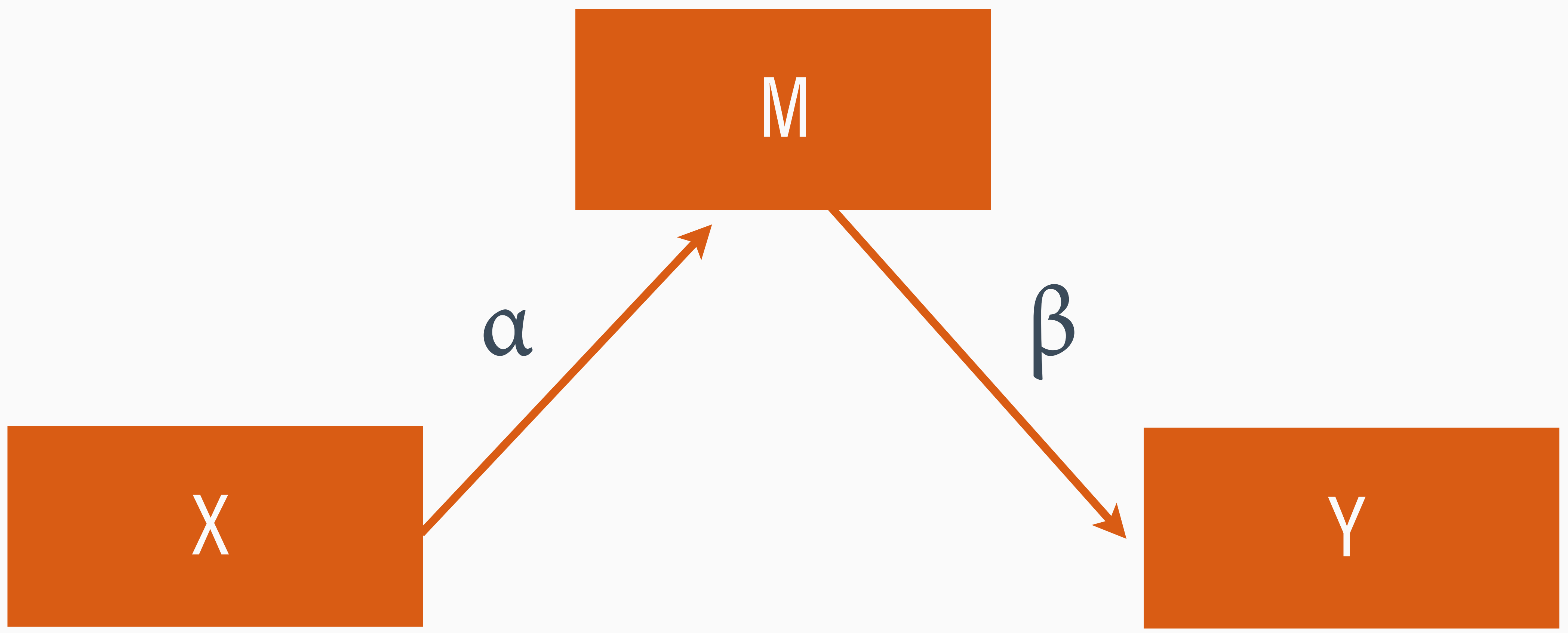
MEDIATION

- A mediation analysis attempts to clarify the mechanism through which two variables are related

- A typical model features an explanatory variable affecting an intervening variable (the mediator) that, in turn, transmits the predictor's influence to the outcome

PATH DIAGRAMS

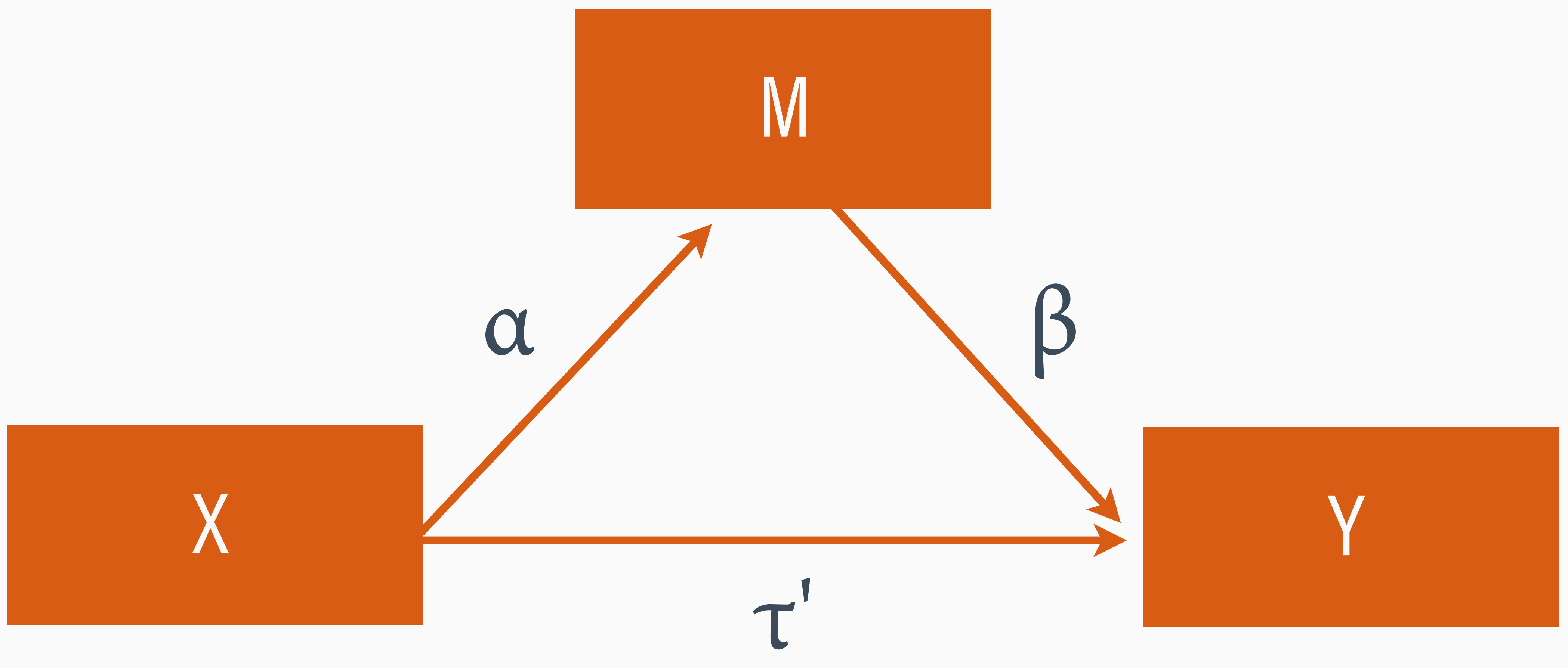
X–Y relation completely explained by indirect effect via M



$$M_i = I_M + \alpha(X_i) + \varepsilon_{Mi}$$

$$Y_i = I_Y + \beta(M_i) + \varepsilon_{Yi}$$

X–Y relation comprised of indirect and direct effect

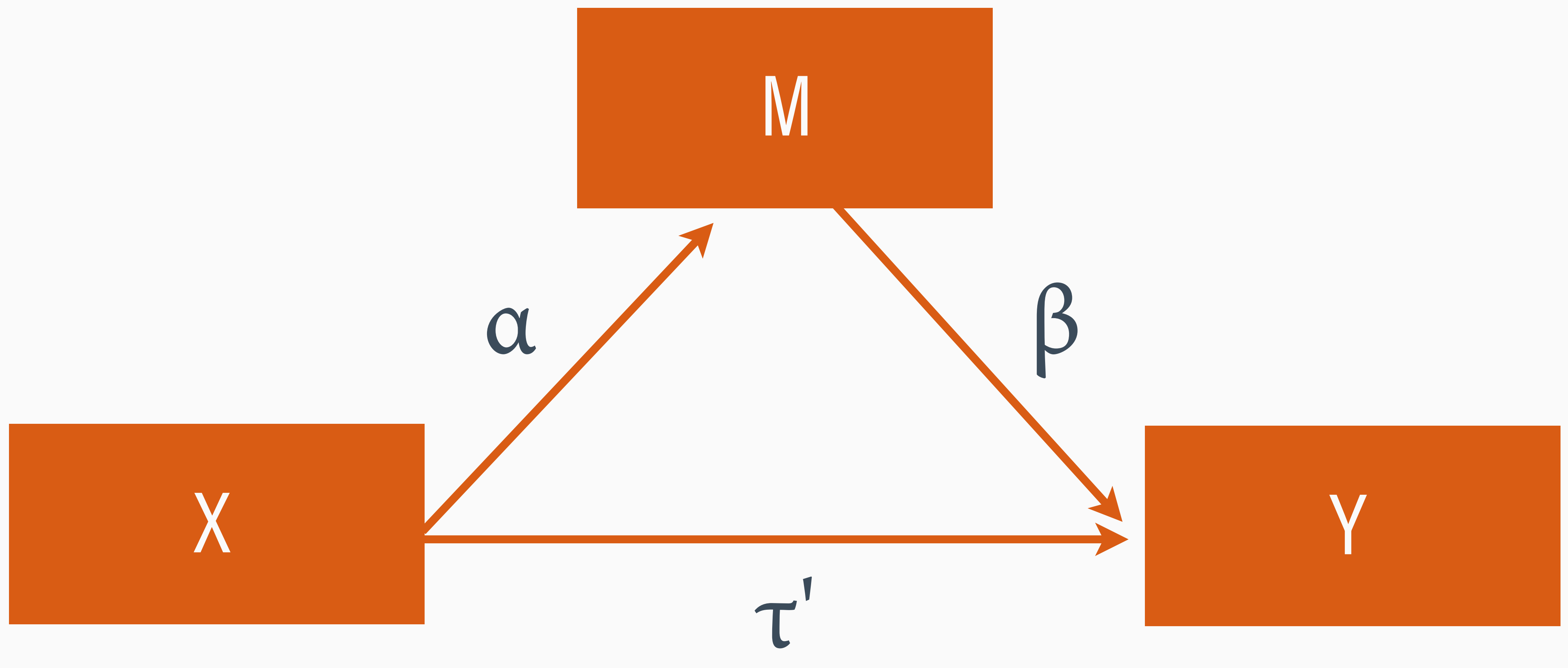


$$M_i = I_M + \alpha(X_i) + \varepsilon_{Mi}$$

$$Y_i = I_Y + \beta(M_i) + \tau'(X_i) + \varepsilon_{Yi}$$

PRODUCT OF COEFFICIENTS ESTIMATOR

- Multiplying the α and β slopes (i.e., the indirect pathways) defines the so-called product of coefficients estimator
- The $\alpha\beta$ product quantifies the influence of X on Y via the mediator M
- The total X–Y association is $\alpha\beta + \tau'$



MEDIATION INFERENCE

- Mediation inference is challenging because the sampling distribution of $\alpha\beta$ can be quite nonnormal
- Using familiar test statistics to get a p-value can lead to incorrect conclusions about the mediated effect
- Bootstrap confidence intervals or MCMC are recommended because they can be asymmetric around the point estimate

MULTILEVEL MEDIATION

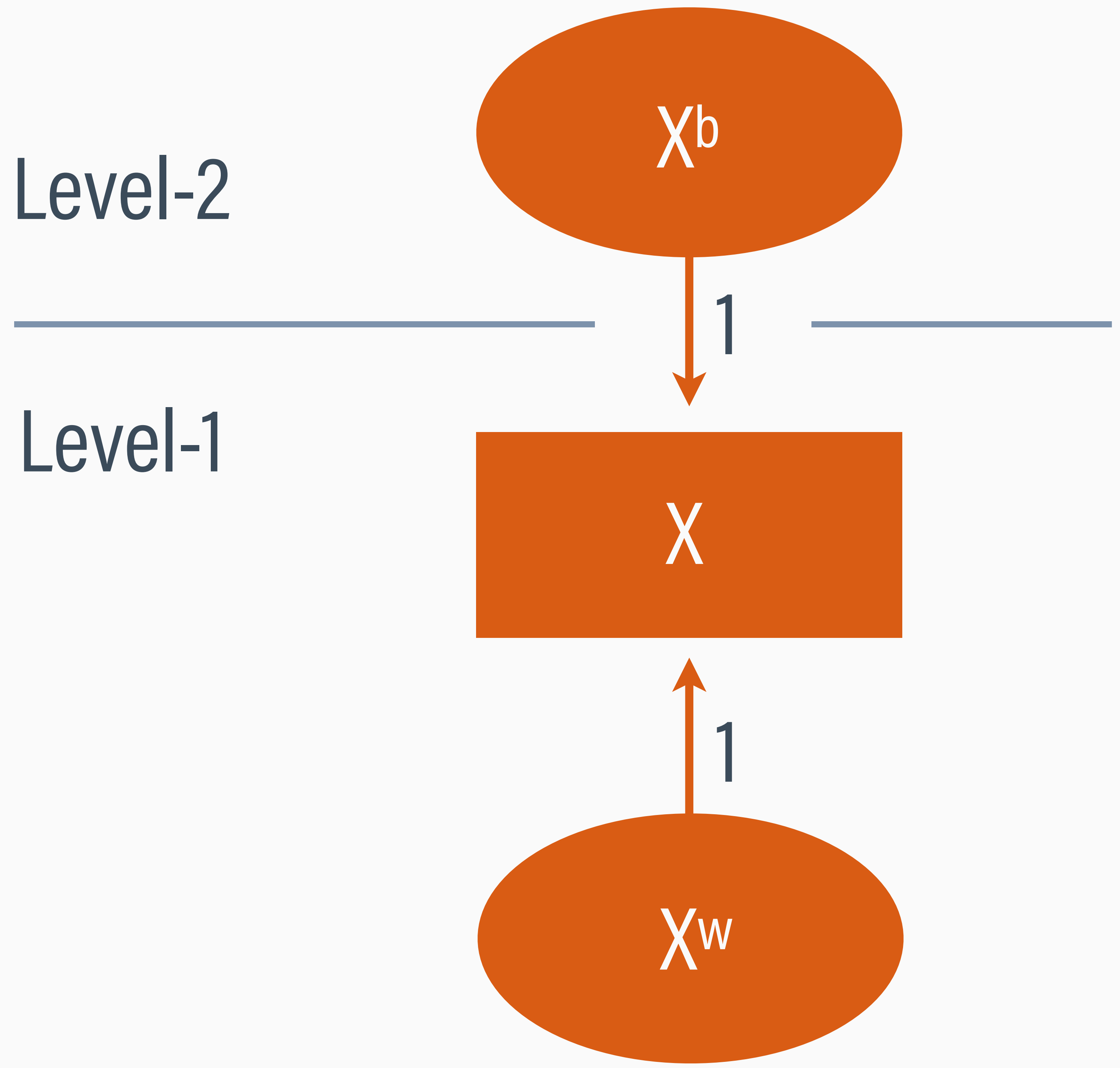
- Multilevel mediation incorporates associations at multiple levels of the data hierarchy
- Variables measured at level-1 have two sources of variation, and mediation can occur at the within and between levels
- Variables measured at level-2 have only level-2 associations

DISAGGREGATION PATH DIAGRAM

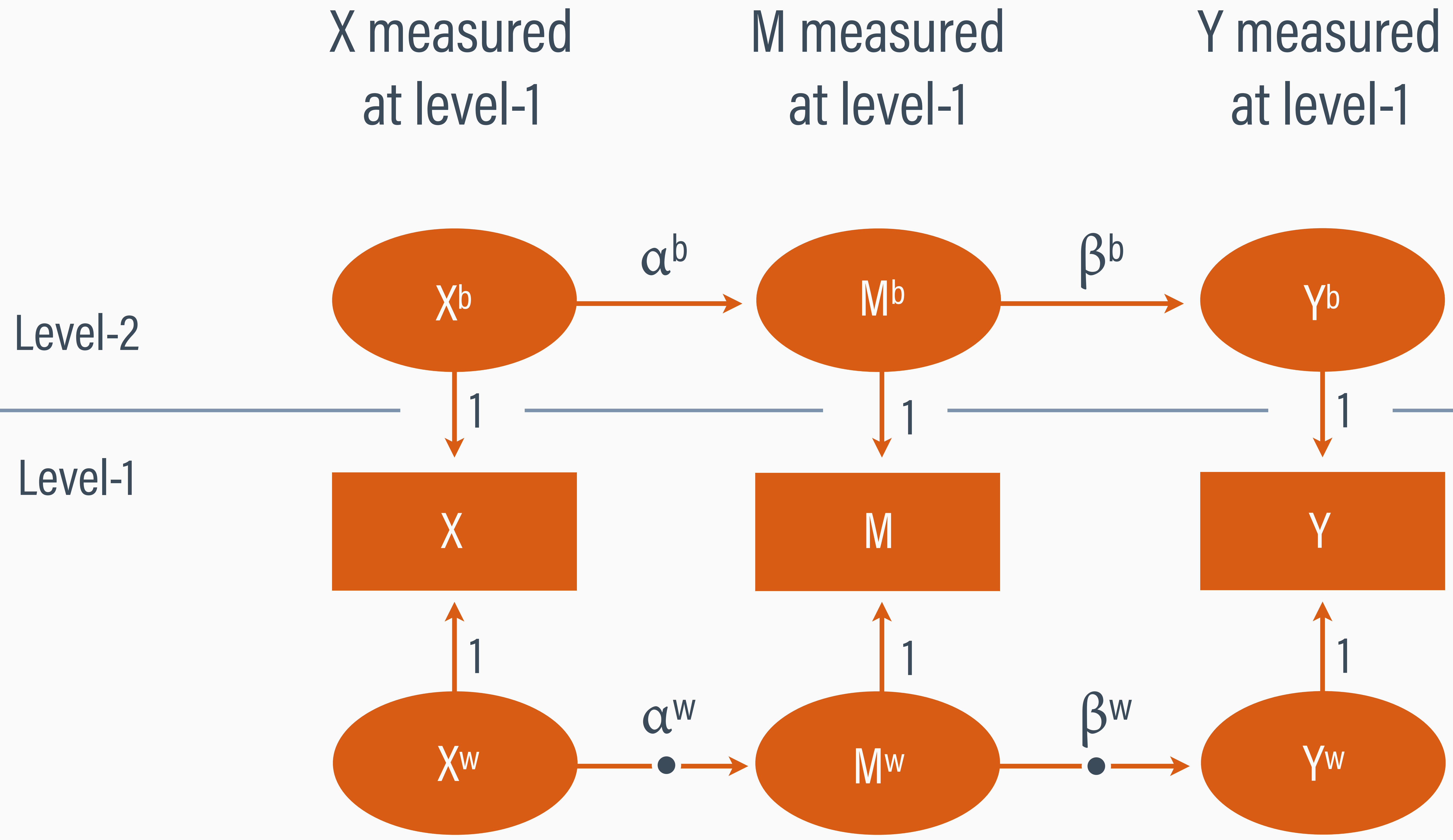
- A variable X is disaggregated into the sum of a cluster mean and within-cluster deviation

$$X_{ij} = X_j^b + X_{ij}^w = \text{cluster mean} + \text{within-cluster deviation}$$

- The rectangle represents the original variable, circles are the disaggregated components, and the 1s on the arrows convey that X^b and X^w contribute equally to X

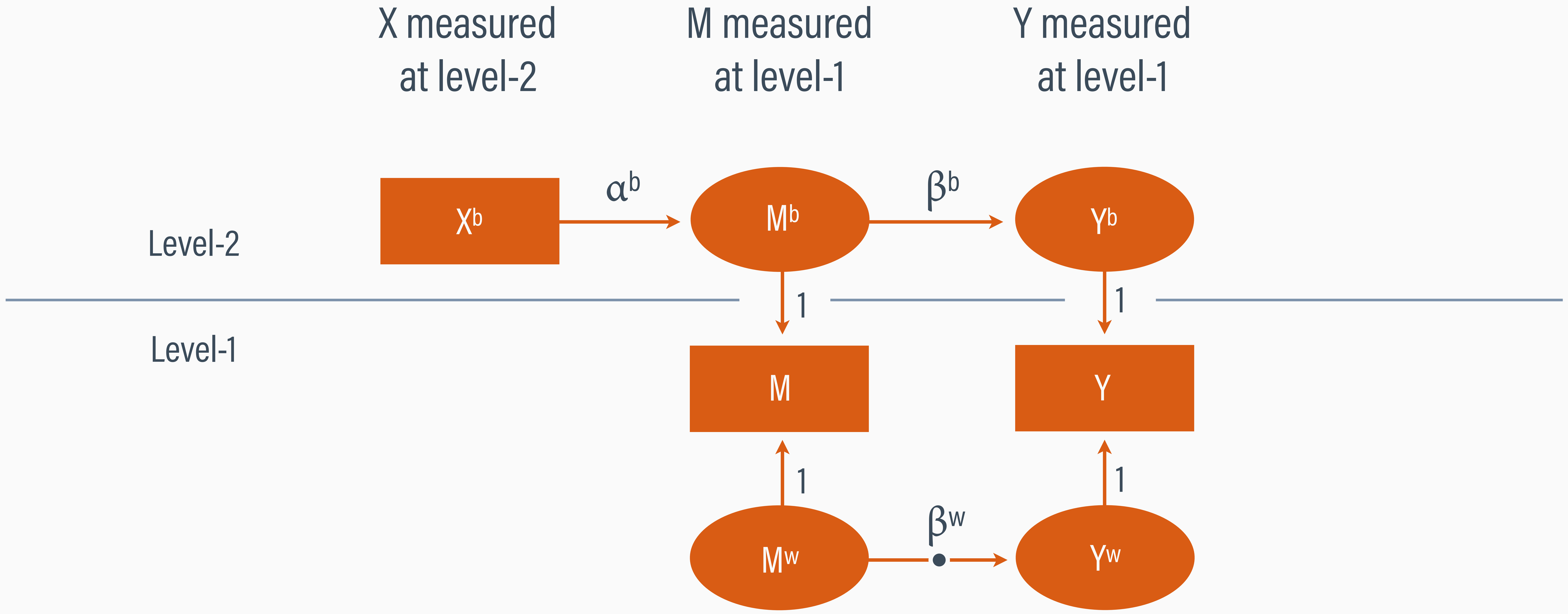


1-1-1 PATH DIAGRAM



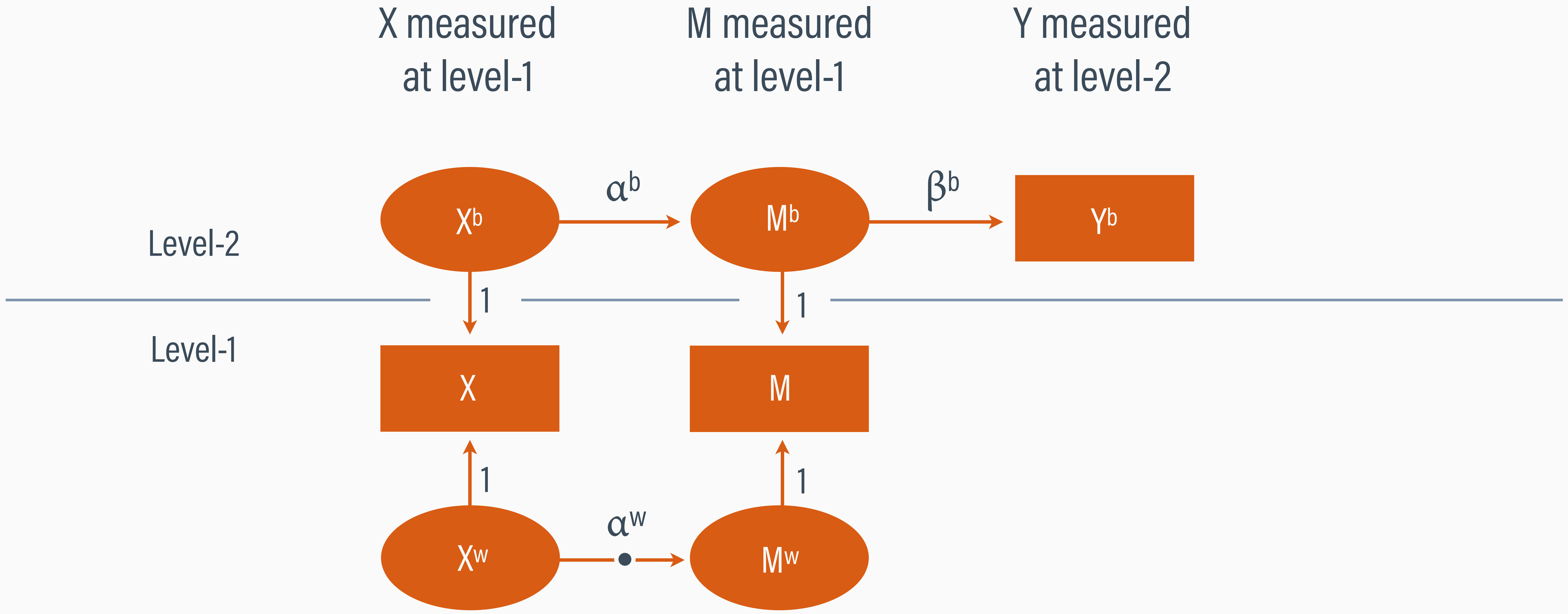
- level-1 slopes may or may not be random

2-1-1 PATH DIAGRAM



- level-1 slopes may or may not be random

1-1-2 PATH DIAGRAM



- level-1 slopes may or may not be random

MLM MEDIATION INFERENCE

- Bootstrapping is complex with multilevel data because there are multiple approaches to resampling
- Resample only level-2 units; resample level-2 units, then resample level-1 units within each chosen level-2 unit
- Bayesian MCMC estimation automatically provides appropriate asymmetric 95% limits

RANDOM SLOPE VARIATION

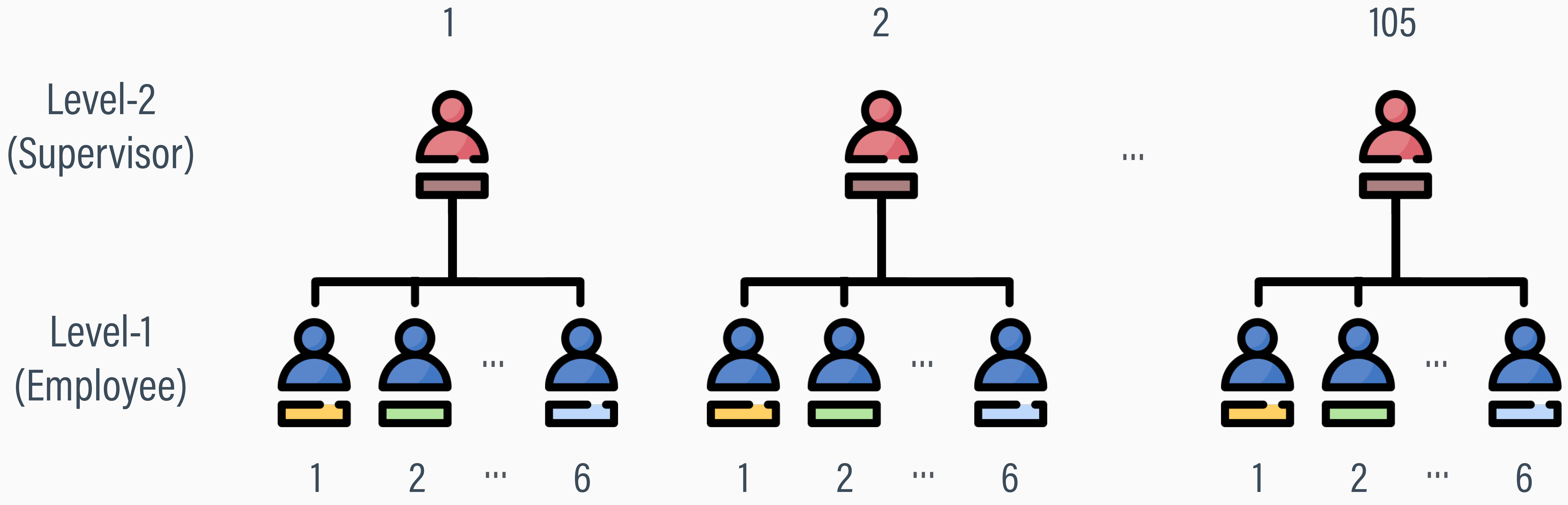
- Cluster-specific α and β paths (i.e., random slopes in the M and Y models) imply that $\alpha\beta$ can vary across level-2 units
- The product of coefficients estimator changes when both α and β have random slope variation
- We need to use multilevel structural equation modeling …

OUTLINE

1. Mediation Overview
2. 1–1–1 Model With Random Intercepts
3. 1–1–1 Model With Random Slopes
4. Moderation on the α or β paths

ORGANIZATIONAL APPLICATION

- n_j = 6 employees at level-1 nested within J = 105 teams or workgroups at level-2 (N = 630 data records in total)



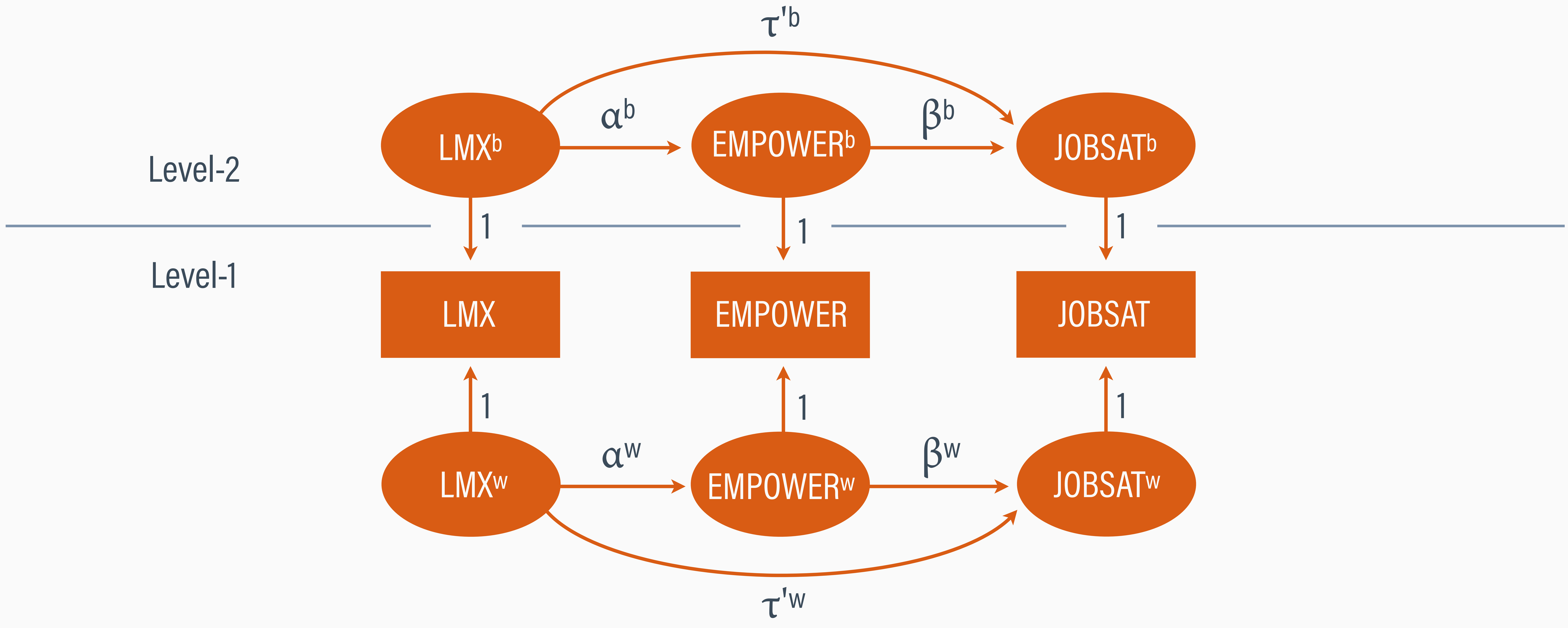
VARIABLE INFORMATION

Predictor
Mediator
Outcome

Variable	Definition	Level	Scale
Team	Team-level (level-2) identifier	2	Integers (1 to 105)
LMX	Leader–member exchange (relationship quality)	1	Numeric (0 to 17)
Empower	Employee empowerment	1	Numeric (14 to 42)
Jobsat	Job satisfaction rating	1	Numeric (0 to 17)

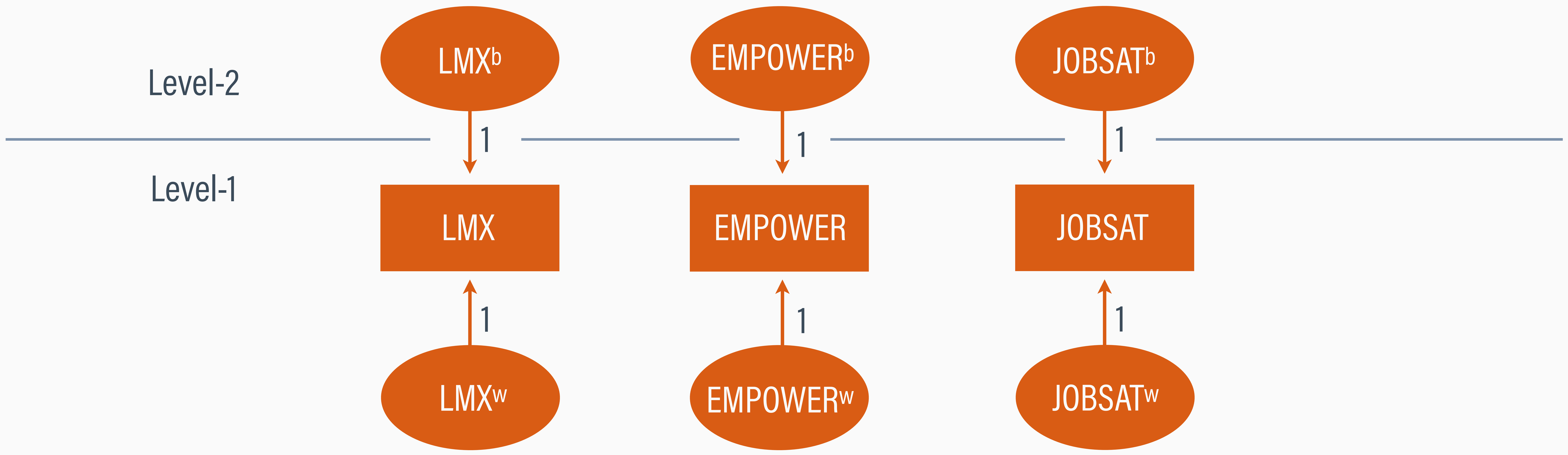
PATH DIAGRAM

- Within- and between-cluster mediation at level-1 and level-2



STARTING SIMPLE: EMPTY MODELS

- Disaggregated level-1 variables with no associations



WITHIN-CLUSTER (LEVEL-1) MODELS

- Each level-1 score is the sum of a level-2 cluster (team) average and a within-cluster residual

$$lmx_{ij} = lmx_j^b + \varepsilon_{ij(lmx)}$$

$$empower_{ij} = empower_j^b + \varepsilon_{ij(empower)}$$

$$jobsat_{ij} = jobsat_j^b + \varepsilon_{ij(jobsat)}$$

- The cluster means are level-2 latent variables (i.e., random intercepts or random effects) instead of arithmetic means

BLIMP SCRIPT 7.1 EXCERPT

$$lmx_{ij} = lmx_j^b + \varepsilon_{ij(lmx)}$$

$$empower_{ij} = empower_j^b + \varepsilon_{ij(empower)}$$

$$jobsat_{ij} = jobsat_j^b + \varepsilon_{ij(jobsat)}$$

```
CLUSTERID: Team;
LATENT: Team = LMX_b Empower_b JobSat_b;  # define team-level latent variables
MODEL:
LMX ~ intercept@LMX_b;   # set level-1 equation's intercept to the level-2 cluster mean
Empower ~ intercept@Empower_b;
JobSat ~ intercept@JobSat_b;
```

BETWEEN-CLUSTER (LEVEL-2) MODELS

- Each level-2 cluster mean is the sum of a grand mean and a level-2 residual

$$lmx_j^b = \beta_{0(lmx)} + u_{0j(lmx)}$$

$$empower_j^b = \beta_{0(empower)} + u_{0j(empower)}$$

$$jobsat_j^b = \beta_{0(jobsat)} + u_{0j(jobsat)}$$

- The cluster means are normally distributed level-2 latent variables (i.e., random intercepts or random effects)

BLIMP SCRIPT 7.1 EXCERPT

$$lmx_j^b = \beta_{0(lmx)} + u_{0j(lmx)}$$

$$empower_j^b = \beta_{0(empower)} + u_{0j(empower)}$$

$$jobsat_j^b = \beta_{0(jobsat)} + u_{0j(jobsat)}$$

```
CLUSTERID: Team;
LATENT: Team = LMX_b Empower_b JobSat_b;  # define team-level latent variables
MODEL:
LMX_b ~ intercept;  # empty level-2 equations
Empower_b ~ intercept;
JobSat_b ~ intercept;
LMX ~ intercept@LMX_b;   # set level-1 equation's intercept to the level-2 cluster mean
Empower ~ intercept@Empower_b;
JobSat ~ intercept@JobSat_b;
```

OUTPUT HOUSEKEEPING

```
CLUSTERID: Team;
LATENT: Team = LMX_b Empower_b JobSat_b;  # define team-level latent variables
MODEL:
level2:  # arbitrary label that groups summary tables for a set of models
LMX_b ~ intercept;
Empower_b ~ intercept;
JobSat_b ~ intercept;
level1:   # arbitrary label that groups summary tables for a set of models
LMX ~ intercept@LMX_b;
Empower ~ intercept@Empower_b;
JobSat ~ intercept@JobSat_b;
```

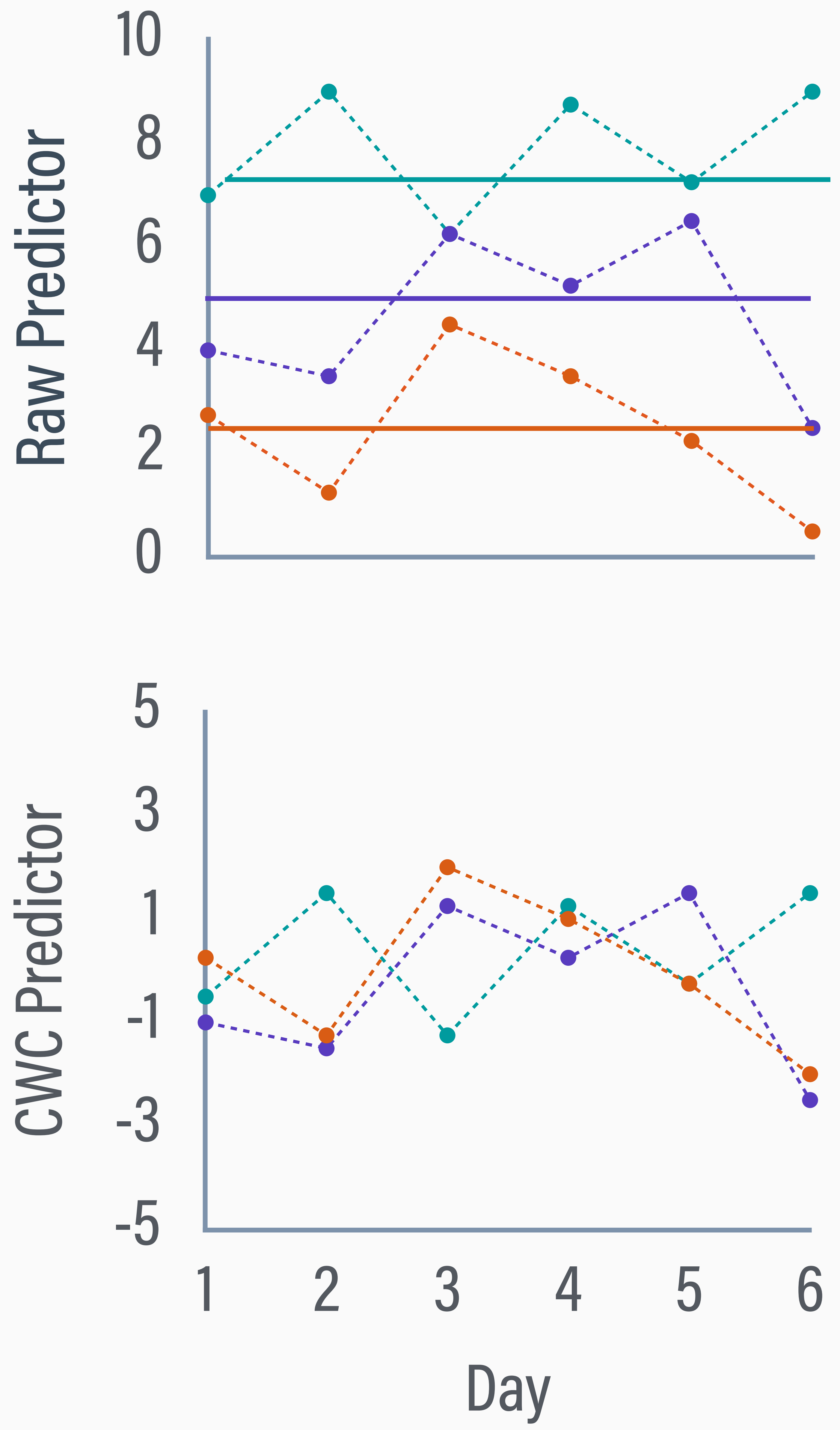
CENTERING LEVEL-1 PREDICTORS

- Pure within-cluster predictors are created by deviating (centering) each person's score at its level-2 team mean

$$lmx_{ij}^{w} = lmx_{ij} - lmx_{j}^{b}$$

$$empower_{ij}^{w} = empower_{ij} - empower_{j}^{b}$$

- The resulting deviation scores contain only within-team (level-1) variation



BLIMP SCRIPT 7.1 EXCERPT

$$lmx_{ij}^{w} = lmx_{ij} - lmx_{j}^{b}$$

$$empower_{ij}^{w} = empower_{ij} - empower_{j}^{b}$$

```
CLUSTERID: Team;
LATENT: Team = LMX_b Empower_b JobSat_b;
MODEL:
LMX_w = LMX – LMX_b;   # text substitution alias to simplify the equations
Empower_w = Empower – Empower_b;  # text substitution alias to simplify the equations
level2:
LMX_b ~ intercept;
Empower_b ~ intercept;
JobSat_b ~ intercept;
level1:
LMX ~ intercept@LMX_b;
Empower ~ intercept@Empower_b;
JobSat ~ intercept@JobSat_b;
```

WITHIN-CLUSTER MEDIATION MODELS

- Level-1 slopes represent “pure’ within-team associations

$$lmx_{ij} = lmx_j^b + \varepsilon_{ij(lmx)}$$

$$empower_{ij} = empower_j^b + \alpha^w(lmx_{ij}^W) + \varepsilon_{ij(empower)}$$

$$jobsat_{ij} = jobsat_j^b + \tau'^w(lmx_{ij}^W) + \beta^w(empower_{ij}^W) + \varepsilon_{ij(jobsat)}$$

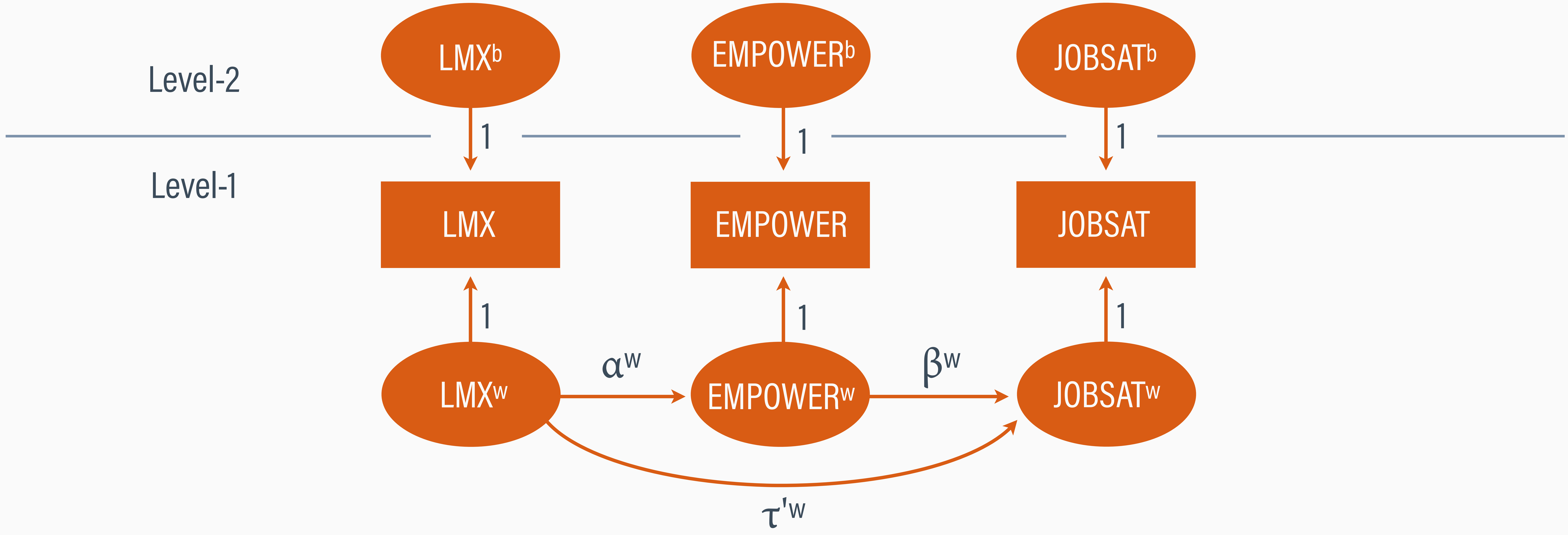
- The random intercepts (team averages) vary across teams

PATH DIAGRAM

$$lmx_{ij} = lmx_j^b + \varepsilon_{ij(lmx)}$$

$$empower_{ij} = empower_j^b + \alpha^w(lmx_{ij}^w) + \varepsilon_{ij(empower)}$$

$$jobsat_{ij} = jobsat_j^b + \tau'^w(lmx_{ij}^w) + \beta^w(empower_{ij}^w) + \varepsilon_{ij(jobsat)}$$



BLIMP SCRIPT 7.1 EXCERPT

$$lmx_{ij} = lmx_j^b + \varepsilon_{ij(lmx)}$$

$$empower_{ij} = empower_j^b + \alpha^w(lmx_{ij}^w) + \varepsilon_{ij(empower)}$$

$$jobsat_{ij} = jobsat_j^b + \tau'^w(lmx_{ij}^w) + \beta^w(empower_{ij}^w) + \varepsilon_{ij(jobsat)}$$

```
CLUSTERID: Team;
LATENT: Team = LMX_b Empower_b JobSat_b;
MODEL:
LMX_w = LMX – LMX_b;   # text substitution alias to simplify the equations
Empower_w = Empower – Empower_b;   # text substitution alias to simplify the equations
level2:
...
level1:
LMX ~ intercept@LMX_b;
Empower ~ intercept@Empower_b LMX_w@apath_w;   # @ labels the within-cluster slopes
JobSat ~ intercept@JobSat_b LMX_w@tpath_w Empower_w@bpath_w;   # @ labels the within-cluster slopes
```

BETWEEN-CLUSTER MEDIATION MODELS

- Level-1 slopes represent “pure’ within-team associations

$$lmx_j^b = \beta_{0(lmx)} + u_{0j(lmx)}$$

$$empower_j^b = \beta_{0(empower)} + \alpha^b(lmx_j^b) + u_{0j(empower)}$$

$$jobsat_j^b = \beta_{0(jobsat)} + \tau'^b(lmx_j^b) + \beta^b(empower_j^b) + u_{0j(jobsat)}$$

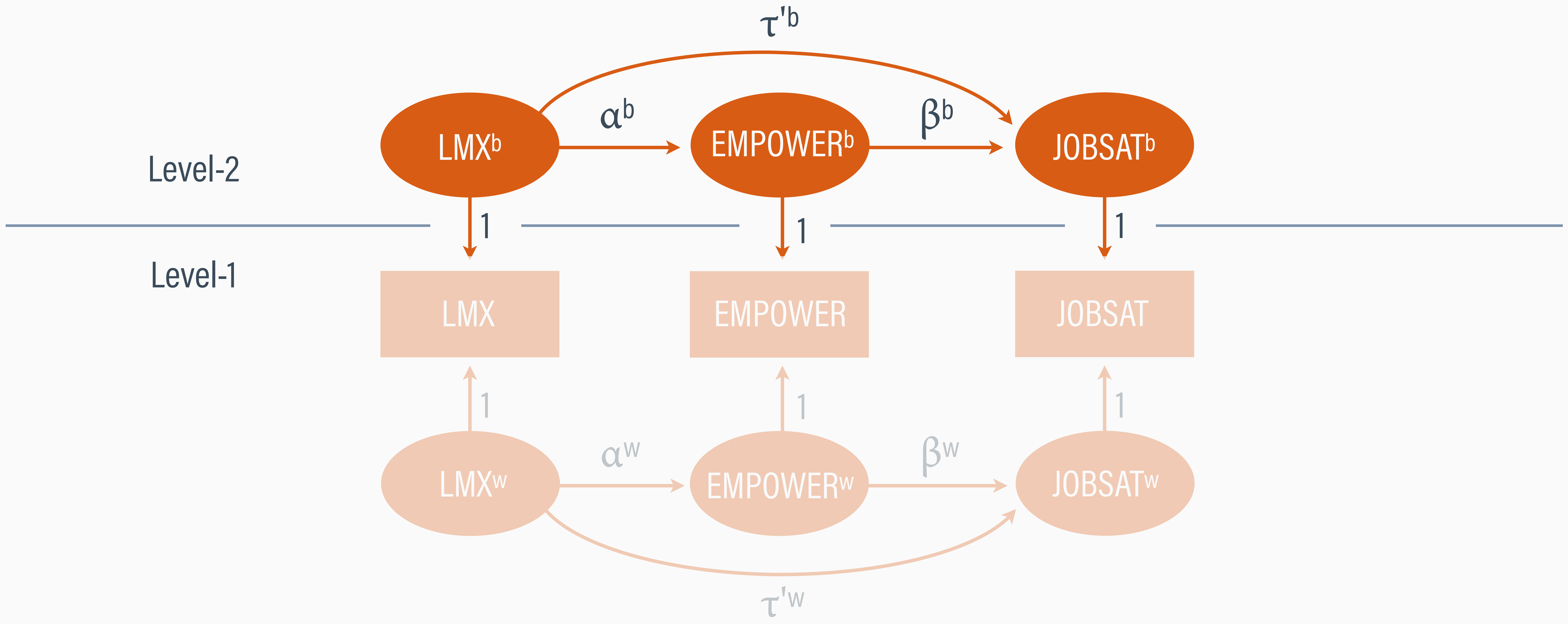
- The random intercepts (team averages) vary across teams

PATH DIAGRAM

$$lmx_j^b = \beta_{0(lmx)} + u_{0j(lmx)}$$

$$empower_j^b = \beta_{0(empower)} + \alpha^b(lmx_j^b) + u_{0j(empower)}$$

$$jobsat_j^b = \beta_{0(jobsat)} + \tau'^b(lmx_j^b) + \beta^b(empower_j^b) + u_{0j(jobsat)}$$



BLIMP SCRIPT 7.1 EXCERPT

$$lmx_j^b = \beta_{0(lmx)} + u_{0j(lmx)}$$

$$empower_j^b = \beta_{0(empower)} + \alpha^b(lmx_j^b) + u_{0j(empower)}$$

$$jobsat_j^b = \beta_{0(jobsat)} + \tau'^b(lmx_j^b) + \beta^b(empower_j^b) + u_{0j(jobsat)}$$

```
CLUSTERID: Team;
LATENT: Team = LMX_b Empower_b JobSat_b;
MODEL:
...
level2:
LMX_b ~ intercept;
Empower_b ~ intercept LMX_b@apath_b;   # @ labels the between-cluster slopes
JobSat_b ~ intercept LMX_b@tpath_b Empower_b@bpath_b;   # @ labels the between-cluster slopes
level1:
...
```

INDIRECT EFFECT ESTIMATES

- An indirect effect is the product of its component slopes

$$\text{Between-cluster indirect effect} = \alpha^{b} \times \beta^{b}$$

$$\text{Within-cluster indirect effect} = \alpha^{w} \times \beta^{w}$$

- The indirect effect is not an estimated parameter, but rather a deterministic function of two estimated slopes

- MCMC produces a distribution of the indirect effect

BLIMP SCRIPT 7.1 EXCERPT

```
MODEL:
LMX_w = LMX – LMX_b;   # text substitution alias to simplify the equations
Empower_w = Empower – Empower_b;
level2:   # arbitrary label that groups summary tables for a set of models
LMX_b ~ intercept;
Empower_b ~ intercept LMX_b@apath_b;   # @ labels the between-cluster slopes
JobSat_b ~ intercept LMX_b@tpath_b Empower_b@bpath_b;
level1:   # arbitrary label that groups summary tables for a set of models
LMX ~ intercept@LMX_b;
Empower ~ intercept@Empower_b LMX_w@apath_w;   # @ labels the within-cluster slopes
JobSat ~ intercept@JobSat_b LMX_w@tpath_w Empower_w@bpath_w;
PARAMETERS:
ab_w = apath_w * bpath_w;   # use slope labels to define the indirect effect estimates
ab_b = apath_b * bpath_b;
```

RBLIMP SCRIPT 7 (MODEL 1) EXCERPT

```
model1 <- rblimp(...
        latent = 'Team = LMX_b Empower_b JobSat_b',
        model = '
          LMX_w = LMX – LMX_b;   # text substitution alias to simplify the equations
          Empower_w = Empower – Empower_b;
          level2:   # arbitrary label that groups summary tables for a set of models
          LMX_b ~ intercept;
          Empower_b ~ intercept LMX_b@apath_b;   # @ labels the between-cluster slopes
          JobSat_b ~ intercept LMX_b@tpath_b Empower_b@bpath_b;
          level1:   # arbitrary label that groups summary tables for a set of models
          LMX ~ intercept@LMX_b;
          Empower ~ intercept@Empower_b LMX_w@apath_w;   # @ labels the within-cluster slopes
          JobSat ~ intercept@JobSat_b LMX_w@tpath_w Empower_w@bpath_w;',
        parameters =  '
         ab_w = apath_w * bpath_w;   # use slope labels to define the indirect effect estimates
          ab_b = apath_b * bpath_b;',      ...)
output(model1)
plot_posterior(model1, 'ab_w')   # plot distribution of indirect effect parameter
plot_posterior(model1, 'ab_b')
```

WITHIN-CLUSTER α^w PATH

= level-2 estimate

= level-1 estimate

Outcome Variable: Empower

Parameters	Estimate	StdDev	2.5%	97.5%	ChiSq	PValue	N_Eff
Variances:							
Residual Var.	14.436	0.899	12.820	16.320	---	---	6508.903
Coefficients:							
Empower_b	@ 1.000	---	---	---	---	---	---
LMX_w	**0.687**	0.059	0.570	0.801	135.816	0.000	5674.431
Standardized Coefficients:							
LMX_w	0.453	0.033	0.385	0.515	186.307	0.000	4602.107
Proportion Variance Explained							
by Coefficients	0.205	0.030	0.148	0.265	---	---	4523.272
by Residual Variation	0.795	0.030	0.735	0.852	---	---	4523.272

WITHIN-CLUSTER β^{w} AND τ'^{w} PATHS

= level-2 estimate

= level-1 estimate

```
Outcome Variable:  JobSat

Parameters                       Estimate    StdDev      2.5%     97.5%     ChiSq    PValue     N_Eff
                              ---------------------------------------------------------------------
Variances:
  Residual Var.                     1.173     0.071     1.043     1.322       ---       ---  6223.732

Coefficients:
  JobSat_b                        @ 1.000       ---       ---       ---       ---       ---       ---
  LMX_w                             0.161     0.019     0.124     0.198    72.366     0.000  8556.982
  Empower_w                         0.019     0.012    -0.005     0.044     2.486     0.115  8322.604

Standardized Coefficients:
  LMX_w                             0.380     0.041     0.297     0.458    84.752     0.000  8271.061
  Empower_w                         0.069     0.044    -0.016     0.155     2.502     0.114  8480.419

Proportion Variance Explained
  by Coefficients                   0.175     0.029     0.120     0.233       ---       ---  5032.537
  by Residual Variation             0.825     0.029     0.767     0.880       ---       ---  5032.537

                              ---------------------------------------------------------------------
```

INTERPRETATIONS

- $\alpha^w = 0.69$ is the expected empowerment difference between two people *from the same team* with LMX scores that differ by one point

- $\beta^w = 0.02$ is the expected job satisfaction difference between two people from the same team with empowerment scores that differ by one point, holding constant LMX at any value

BETWEEN-CLUSTER α^b PATH

= level-2 estimate

= level-1 estimate

```
Latent Variable:   Empower_b

Parameters                     Estimate    StdDev      2.5%     97.5%     ChiSq    PValue     N_Eff

-----------------------------------------------------------------------------
Variances:
  Residual Var.                   2.400     0.832     1.018     4.255       ---       ---   542.191

Coefficients:
  Intercept                      29.167     3.379    23.373    36.720    75.607     0.000   522.201
  LMX_b                          -0.057     0.351    -0.846     0.546     0.053     0.817   520.579

Standardized Coefficients:
  LMX_b                          -0.040     0.226    -0.520     0.353     0.056     0.813   477.866

Proportion Variance Explained
  by Coefficients                 0.024     0.077     0.000     0.273       ---       ---   498.597
  by Residual Variation           0.976     0.077     0.727     1.000       ---       ---   498.597


-----------------------------------------------------------------------------
```

BETWEEN-CLUSTER β^b AND τ'^b PATHS

= level-2 estimate

= level-1 estimate

Latent Variable: JobSat_b

Parameters	Estimate	StdDev	2.5%	97.5%	ChiSq	PValue	N_Eff
Variances:							
Residual Var.	0.059	0.044	0.003	0.168	---	---	239.018
Coefficients:							
Intercept	-2.992	2.347	-9.284	0.381	2.021	0.155	196.419
LMX_b	**0.205**	0.091	0.053	0.414	5.423	0.020	345.646
Empower_b	**0.178**	0.066	0.078	0.344	7.973	0.005	195.484
Standardized Coefficients:							
LMX_b	0.514	0.184	0.145	0.878	7.743	0.005	414.852
Empower_b	0.649	0.165	0.293	0.949	15.207	0.000	230.355
Proportion Variance Explained							
by Coefficients	0.669	0.200	0.243	0.984	---	---	186.171
by Residual Variation	0.331	0.200	0.016	0.757	---	---	186.171

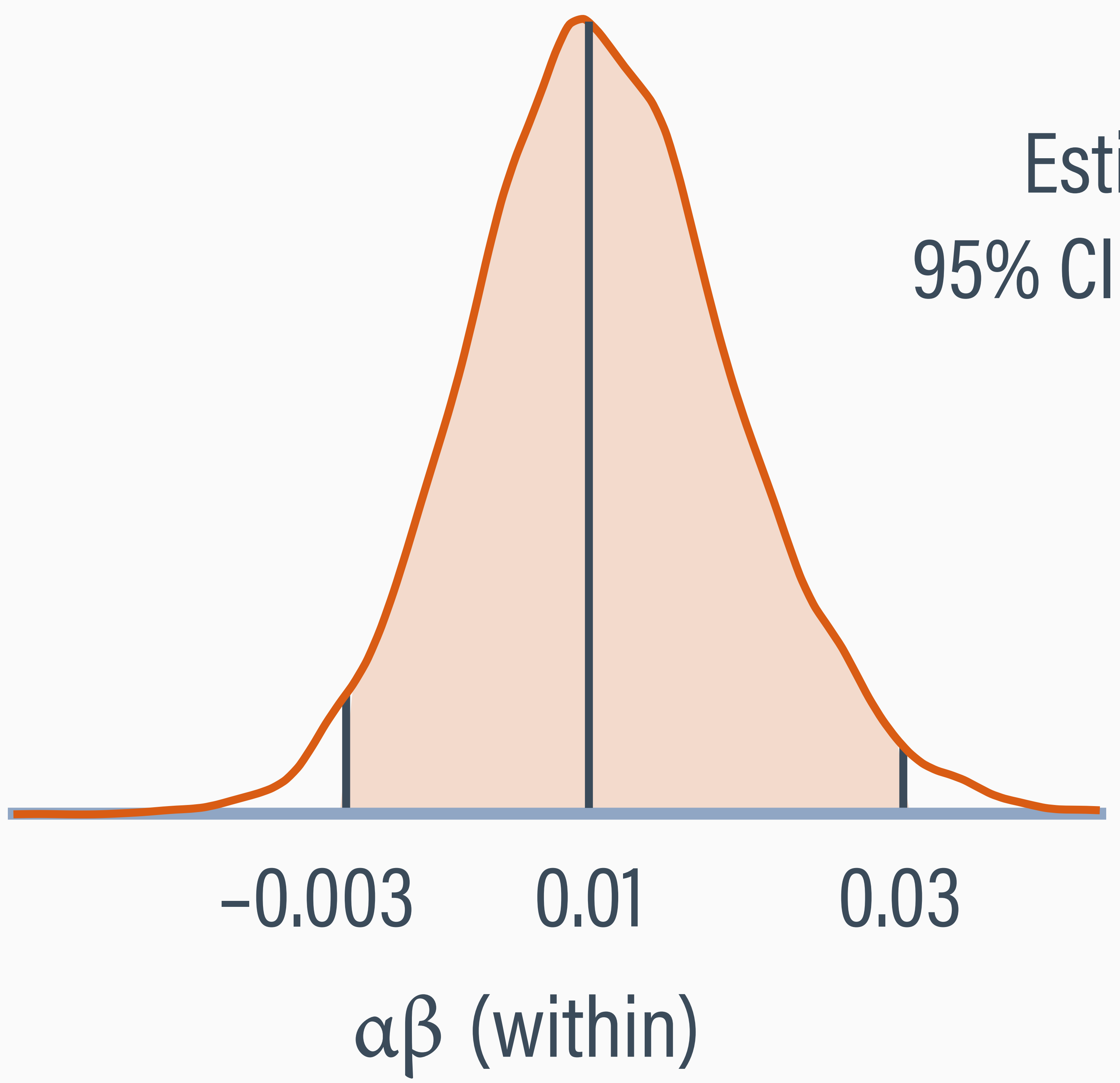
INTERPRETATIONS

- $\alpha^b = 0.06$ is the expected empowerment mean difference between two teams with average LMX values that differ by one point, controlling for team-average LMX

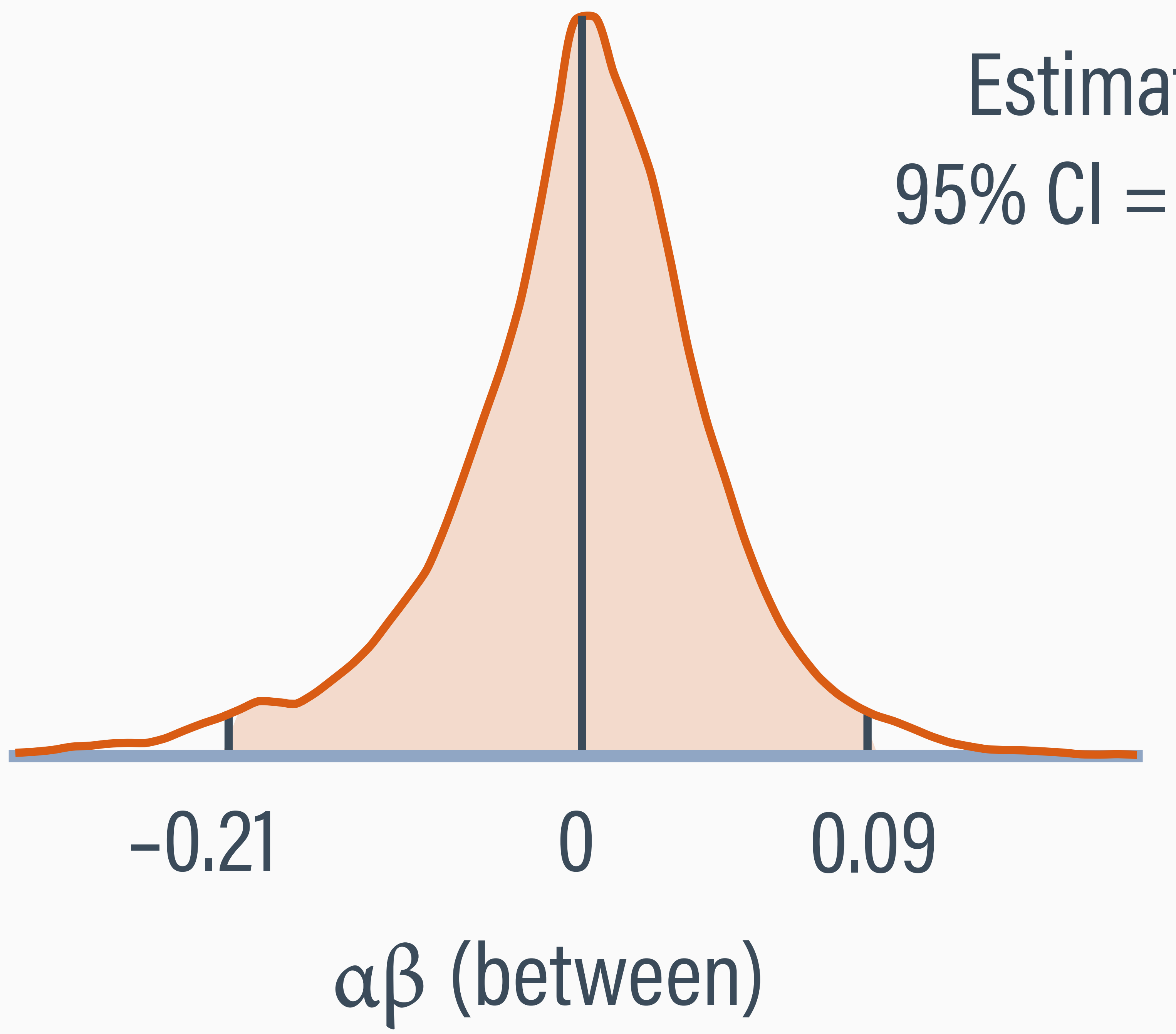
- $\beta^b = 0.18$ is the expected job satisfaction mean difference between two teams with average empowerment values that differ by one point, controlling for team-average LMX

DISTRIBUTIONS OF INDIRECT EFFECTS

- Indirect effects are computed at each MCMC iteration, producing a distribution of plausible mediated effects at each level



Estimate = 0.013
95% CI = (−0.003, 0.031)



Estimate = −0.009
95% CI = (−0.211 0.092)

INDIRECT EFFECTS OUTPUT

= level-2 estimate

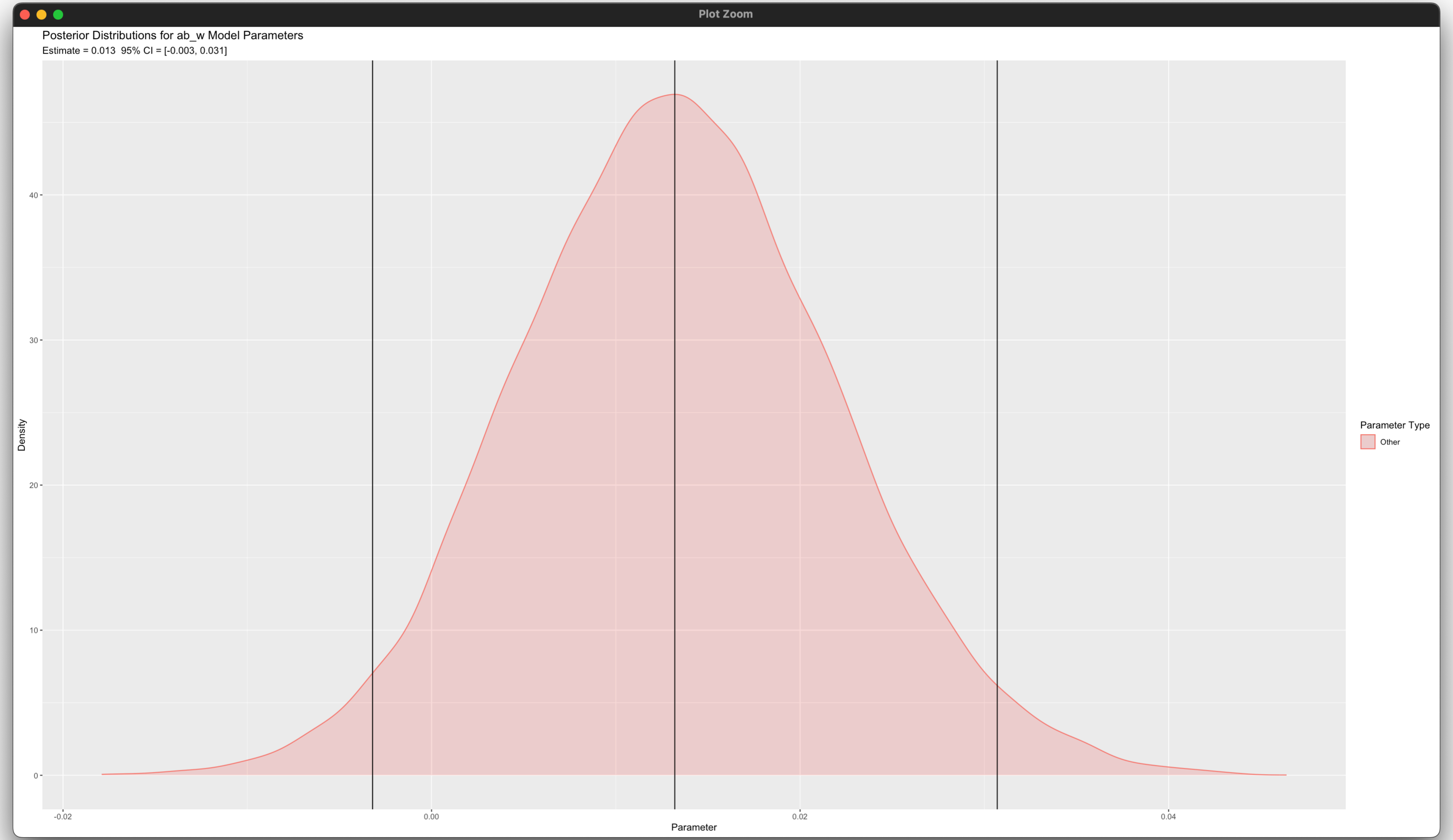
= level-1 estimate

Standard test statistics are inappropriate for evaluating mediated effects!

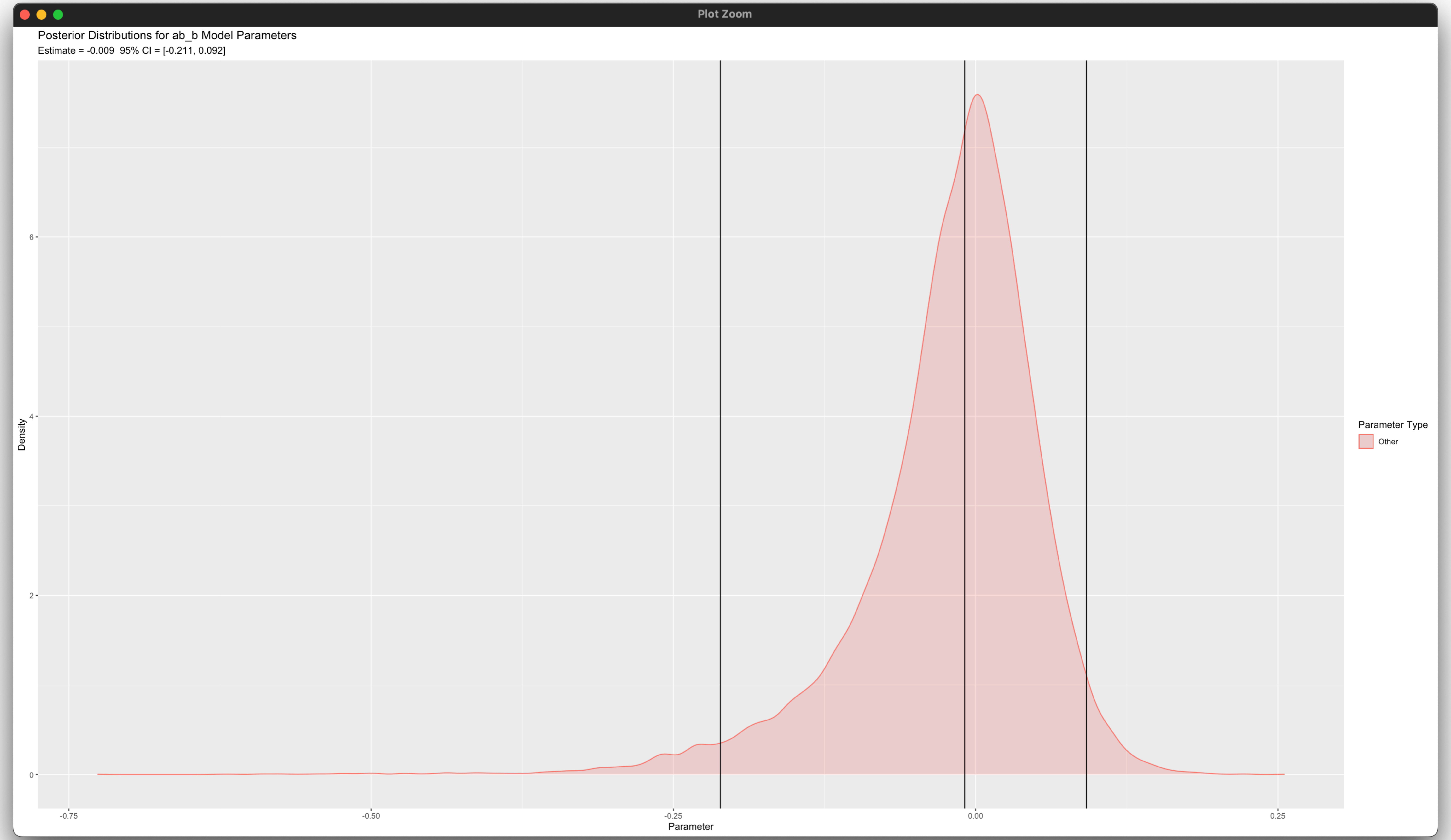
```
GENERATED PARAMETERS:

  Summaries based on 20000 iterations using 2 chains.
  NOTE: Estimate column based on posterior median.
```

Parameters	Estimate	StdDev	2.5%	97.5%	ChiSq	PValue	N_Eff
ab_w	0.013	0.009	-0.003	0.031	2.4[illegible]	[illegible].120	8417.097
ab_b	-0.009	0.075	-0.211	0.092	0.0[illegible]	[illegible].776	368.719

DISTRIBUTION OF $\alpha\beta^{w}$ (RBLIMP ONLY)



DISTRIBUTION OF $\alpha\beta^b$ (RBLIMP ONLY)



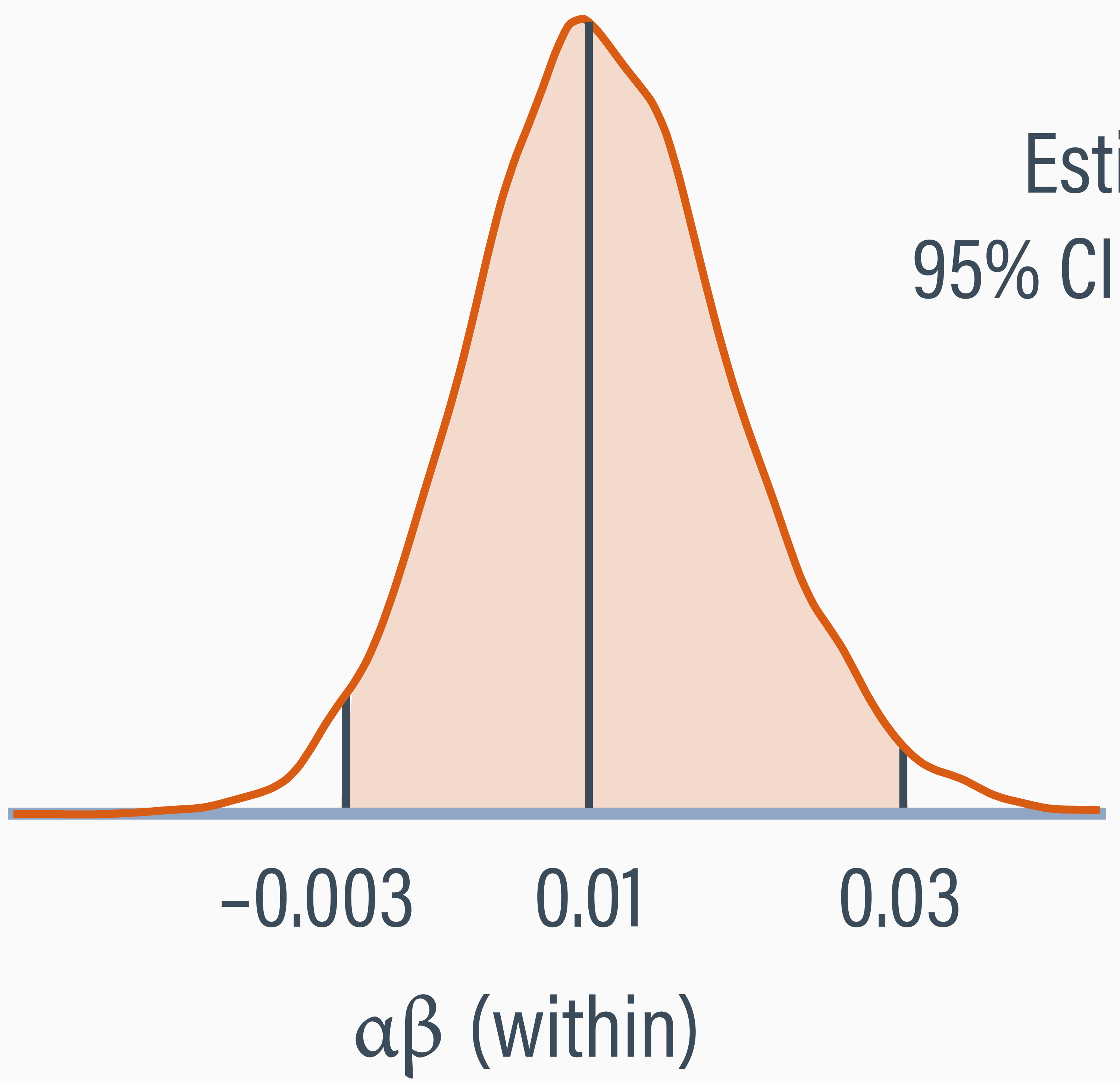
INTERPRETATIONS

- $\alpha\beta^{w}$ = .013 is the effect of a one-point within-team difference on LMX that gets transmitted to job satisfaction via a one-point within-team difference in empowerment (the mediator)

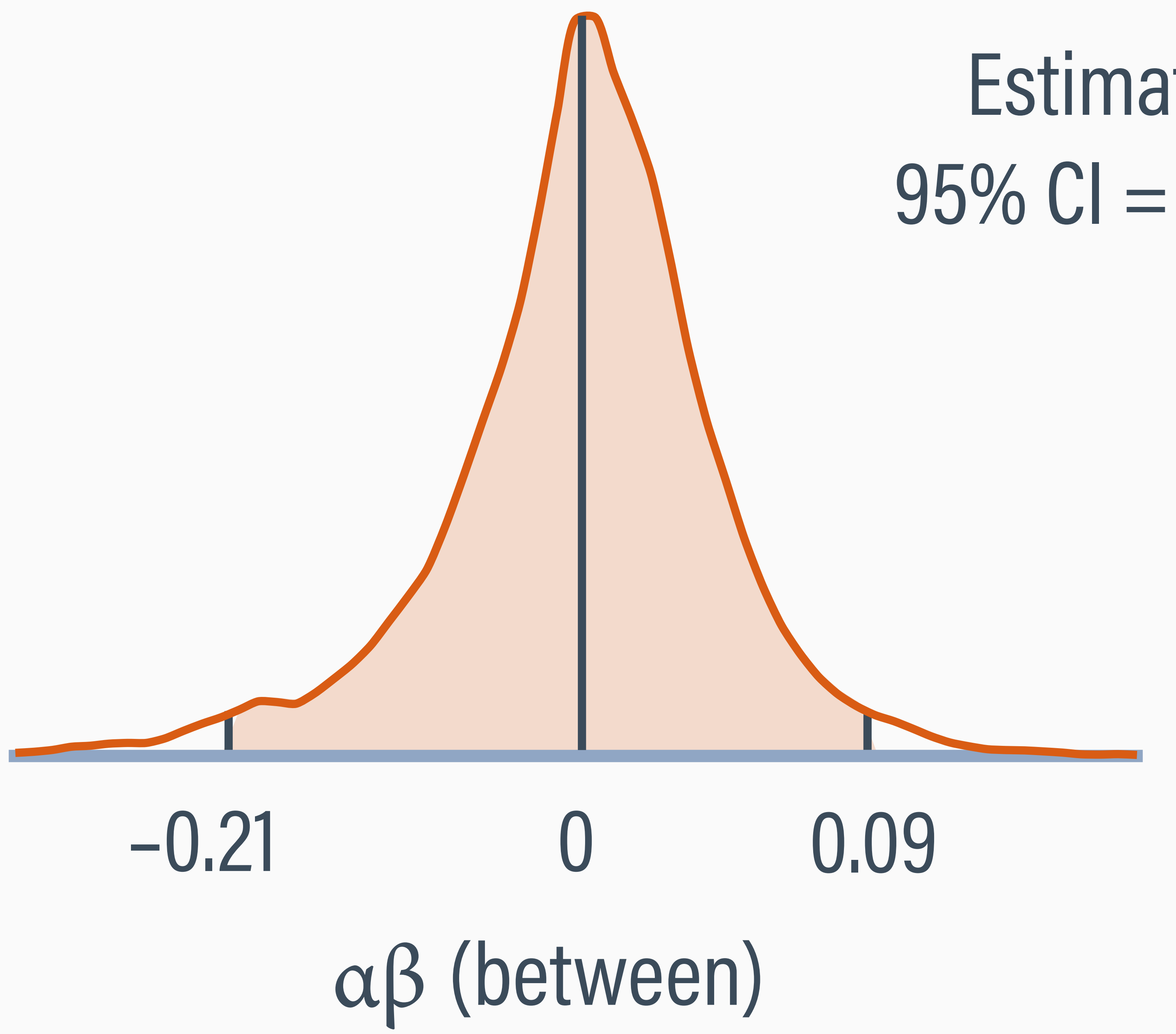
- $\alpha\beta^{b}$ = –0.01 is the effect of a one-point between-team mean difference on LMX that gets transmitted to job satisfaction via a one-point mean difference in empowerment (the mediator)

95% ASYMMETRIC INTERVALS

- Zero is inside both 95% intervals (just barely at level-1), implying that the data could have originated from a population with no mediation



Estimate = 0.013
95% CI = (−0.003, 0.031)



Estimate = −0.009
95% CI = (−0.211 0.092)

OUTLINE

WITHIN-CLUSTER MEDIATION MODELS

- Level-1 slopes represent “pure’ within-team associations

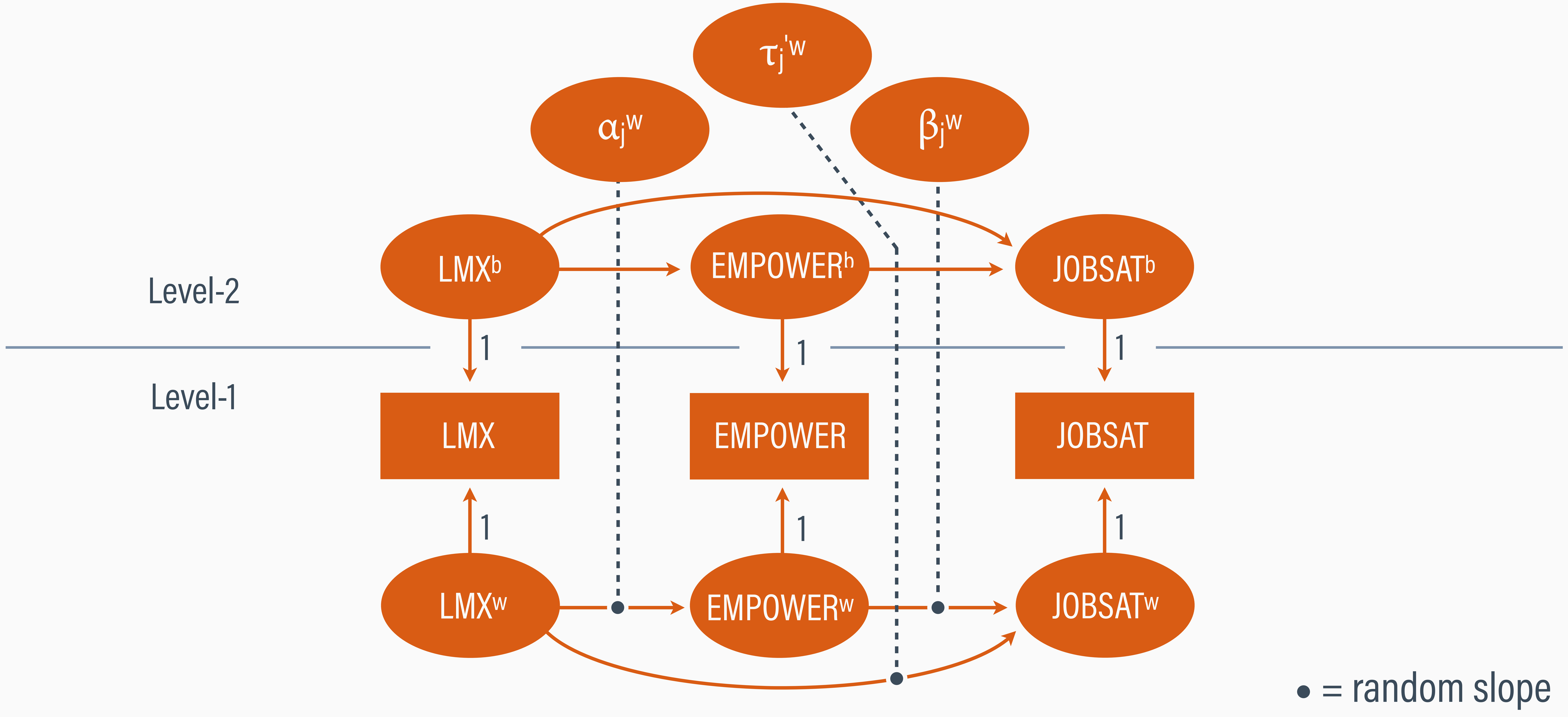
$$lmx_{ij} = lmx_j^b + \varepsilon_{ij(lmx)}$$

$$empower_{ij} = empower_j^b + \alpha_j^w(lmx_{ij}^w) + \varepsilon_{ij(empower)}$$

$$jobsat_{ij} = jobsat_j^b + \tau_j'^w(lmx_{ij}^w) + \beta_j^w(empower_{ij}^w) + \varepsilon_{ij(jobsat)}$$

- Intercepts (team averages) and slopes vary across teams

PATH DIAGRAM



INDIRECT EFFECT ESTIMATES

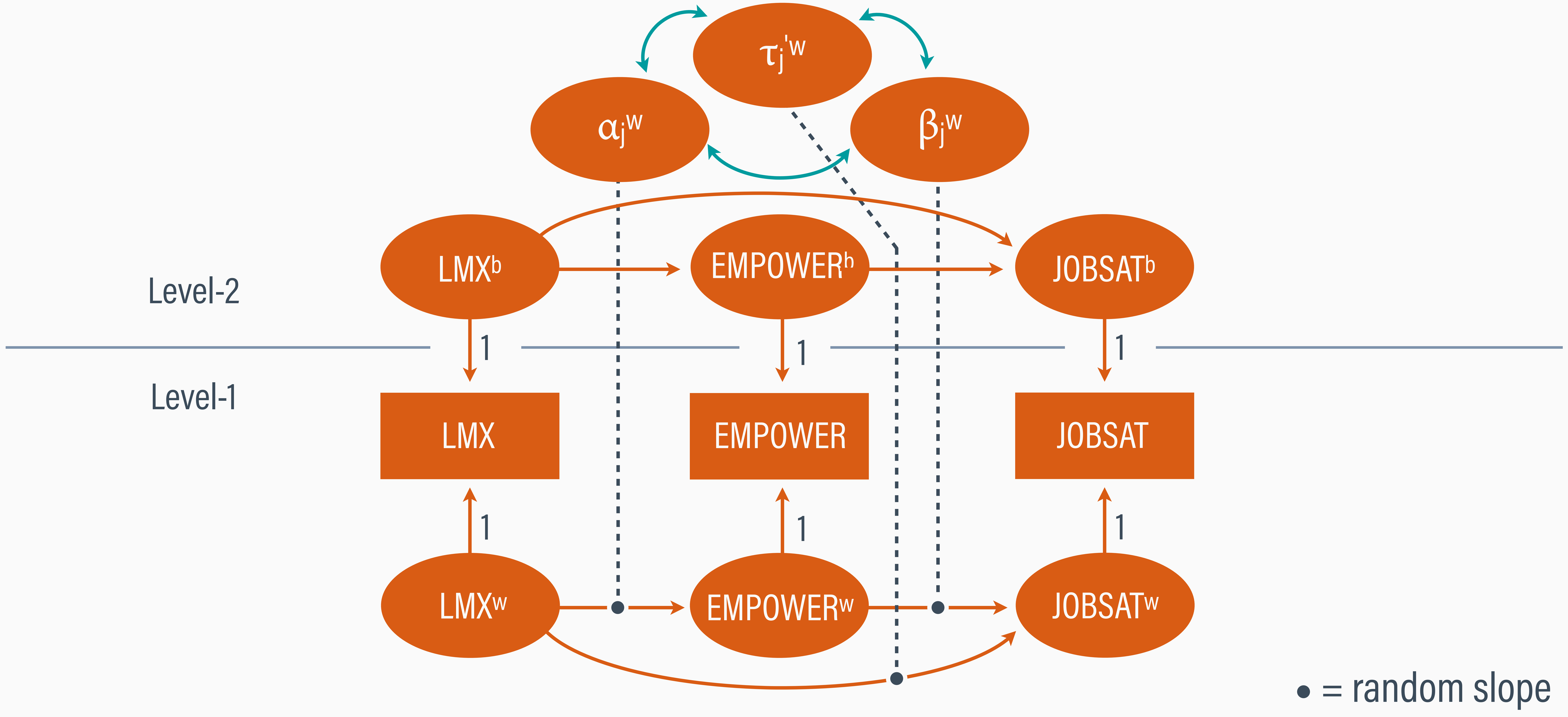
- In a model with random slopes, the within-cluster indirect effect equals the product of α^w and β^w *plus* the covariance (unstandardized correlation) between the random slopes

$$\text{Between-cluster indirect effect} = \alpha^b \times \beta^b$$

$$\text{Within-cluster indirect effect} = \alpha^w \times \beta^w + \text{cov}(\alpha^w, \beta^w)$$

- Correlating slopes in a multilevel SEM is vital for obtaining unbiased indirect effects (Kenny, Korchmaros, & Bolger, 2003)

PATH DIAGRAM



BLIMP SCRIPT 7.2 EXCERPT

```
LATENT: Team = LMX_b Empower_b JobSat_b apath_w bpath_w tpath_w;  # define random slope latent variables
MODEL:
…
level2:
LMX_b ~ intercept;
Empower_b ~ intercept LMX_b@apath_b;
JobSat_b ~ intercept LMX_b@tpath_b Empower_b@bpath_b;
apath_w ~ intercept@apathw_mean;   # random slope latent variables with their means labeled
bpath_w ~ intercept@bpathw_mean;
tpath_w ~ intercept;
apath_w ~~ bpath_w@ab_corr;   # correlate random a and b paths and attach a label;
apath_w bpath_w ~~ tpath_w;    # correlate remaining random slopes
…
```

BLIMP SCRIPT 7.2 EXCERPT

```
LATENT: Team = LMX_b Empower_b JobSat_b apath_w bpath_w tpath_w;  # define random slope latent variables
MODEL:
...
apath_w ~ intercept@apathw_mean;
bpath_w ~ intercept@bpathw_mean;
tpath_w ~ intercept;
apath_w ~~ bpath_w@ab_corr;  # correlate random a and b paths and attach a label;
apath_w bpath_w ~~ tpath_w;  # correlate remaining random slopes
level1:
LMX ~ intercept@LMX_b;
Empower ~ intercept@Empower_b LMX_w@apath_w;  # @ sets the LMX_w slope to its level-2 latent variable
JobSat ~ intercept@JobSat_b LMX_w@tpath_w Empower_w@bpath_w;  # @ sets slopes to their latent variables
```

$$empower_{ij} = empower_j^b + \alpha_j^w(lmx_{ij}^w) + \varepsilon_{ij(empower)}$$

$$jobsat_{ij} = jobsat_j^b + \tau_j'^w(lmx_{ij}^w) + \beta_j^w(empower_{ij}^w) + \varepsilon_{ij(jobsat)}$$

BLIMP SCRIPT 7.2 EXCERPT

```
MODEL:
...
level2:
LMX_b ~ intercept;
Empower_b ~ intercept LMX_b@apath_b;
JobSat_b ~ intercept LMX_b@tpath_b Empower_b@bpath_b;
apath_w ~ intercept@apathw_mean;
bpath_w ~ intercept@bpathw_mean;
tpath_w ~ intercept;
apath_w ~~ bpath_w@ab_corr;   # correlate random a and b paths and attach a label;
apath_w bpath_w ~~ tpath_w;   # correlate remaining random slopes
...
PARAMETERS:
ab_cov = ab_corr * sqrt(apath_w.totalvar * bpath_w.totalvar);   # covariance between random slopes uses .totalvar to get the variance
ab_w = apathw_mean * bpathw_mean + ab_cov;
ab_b = apath_b * bpath_b;
```

WITHIN-CLUSTER α^w PATH

= level-2 estimate

= level-1 estimate

```
Latent Variable:   apath_w

Parameters                         Estimate     StdDev       2.5%      97.5%      ChiSq     PValue      N_Eff
                                -----------------------------------------------------------------------------
Variances:
  Residual Var.                       0.182      0.077      0.068      0.367        ---        ---    689.181

Coefficients:
  Intercept                           0.662      0.073      0.515      0.803     81.727      0.000   1491.264

Proportion Variance Explained
  by Coefficients                     0.000      0.000      0.000      0.000        ---        ---        nan
  by Residual Variation               1.000      0.000      1.000      1.000        ---        ---        nan

                                -----------------------------------------------------------------------------
```

WITHIN-CLUSTER β^{w} PATH

= level-2 estimate

= level-1 estimate

```
Latent Variable:   bpath_w

Parameters                          Estimate      StdDev        2.5%       97.5%       ChiSq      PValue       N_Eff
                                --------------------------------------------------------------------------------
Variances:
  Residual Var.                        0.005       0.003       0.001       0.012         ---         ---     196.246

Coefficients:
  Intercept                            0.025       0.015      -0.005       0.053       2.730       0.098     348.833

Proportion Variance Explained
  by Coefficients                      0.000       0.000       0.000       0.000         ---         ---         nan
  by Residual Variation                1.000       0.000       1.000       1.000         ---         ---         nan

                                --------------------------------------------------------------------------------
```

INTERPRETATIONS

- $\alpha^w = 0.66$ is the expected empowerment difference between two people *from the same team* with LMX scores that differ by one point
- $\beta^w = 0.03$ is the expected job satisfaction difference between two people from the same team with empowerment scores that differ by one point, holding constant LMX at any value

BETWEEN-CLUSTER α^b PATH

= level-2 estimate

= level-1 estimate

```
Latent Variable:   Empower_b

Parameters                          Estimate     StdDev       2.5%      97.5%      ChiSq     PValue      N_Eff

-------------------------------------------------------------------------------
Variances:
  Residual Var.                        2.457      0.810      1.049      4.233        ---        ---    526.462

Coefficients:
  Intercept                           28.583      3.322     22.984     36.210     75.351      0.000    593.906
  LMX_b                                0.005      0.346     -0.790      0.585      0.004      0.948    585.287

Standardized Coefficients:
  LMX_b                                0.003      0.226     -0.515      0.377      0.005      0.945    423.151

Proportion Variance Explained
  by Coefficients                      0.022      0.077      0.000      0.272        ---        ---    273.546
  by Residual Variation                0.978      0.077      0.728      1.000        ---        ---    273.546

-------------------------------------------------------------------------------
```

BETWEEN-CLUSTER β^b AND τ'^b PATHS

= level-2 estimate

= level-1 estimate

```
Latent Variable:   JobSat_b

Parameters                          Estimate     StdDev       2.5%      97.5%      ChiSq     PValue      N_Eff
                               -----------------------------------------------------------------------------
Variances:
  Residual Var.                        0.064      0.045      0.005      0.171        ---        ---    274.358

Coefficients:
  Intercept                           -2.843      2.350     -8.407      0.697      1.731      0.188    194.582
  LMX_b                                0.199      0.090      0.046      0.399      5.199      0.023    318.385
  Empower_b                            0.173      0.067      0.070      0.329      7.183      0.007    209.485

Standardized Coefficients:
  LMX_b                                0.501      0.187      0.121      0.851      7.063      0.008    325.075
  Empower_b                            0.628      0.167      0.277      0.912     13.785      0.000    277.072

Proportion Variance Explained
  by Coefficients                      0.661      0.206      0.205      0.974        ---        ---    240.927
  by Residual Variation                0.339      0.206      0.026      0.795        ---        ---    240.927

                               -----------------------------------------------------------------------------
```

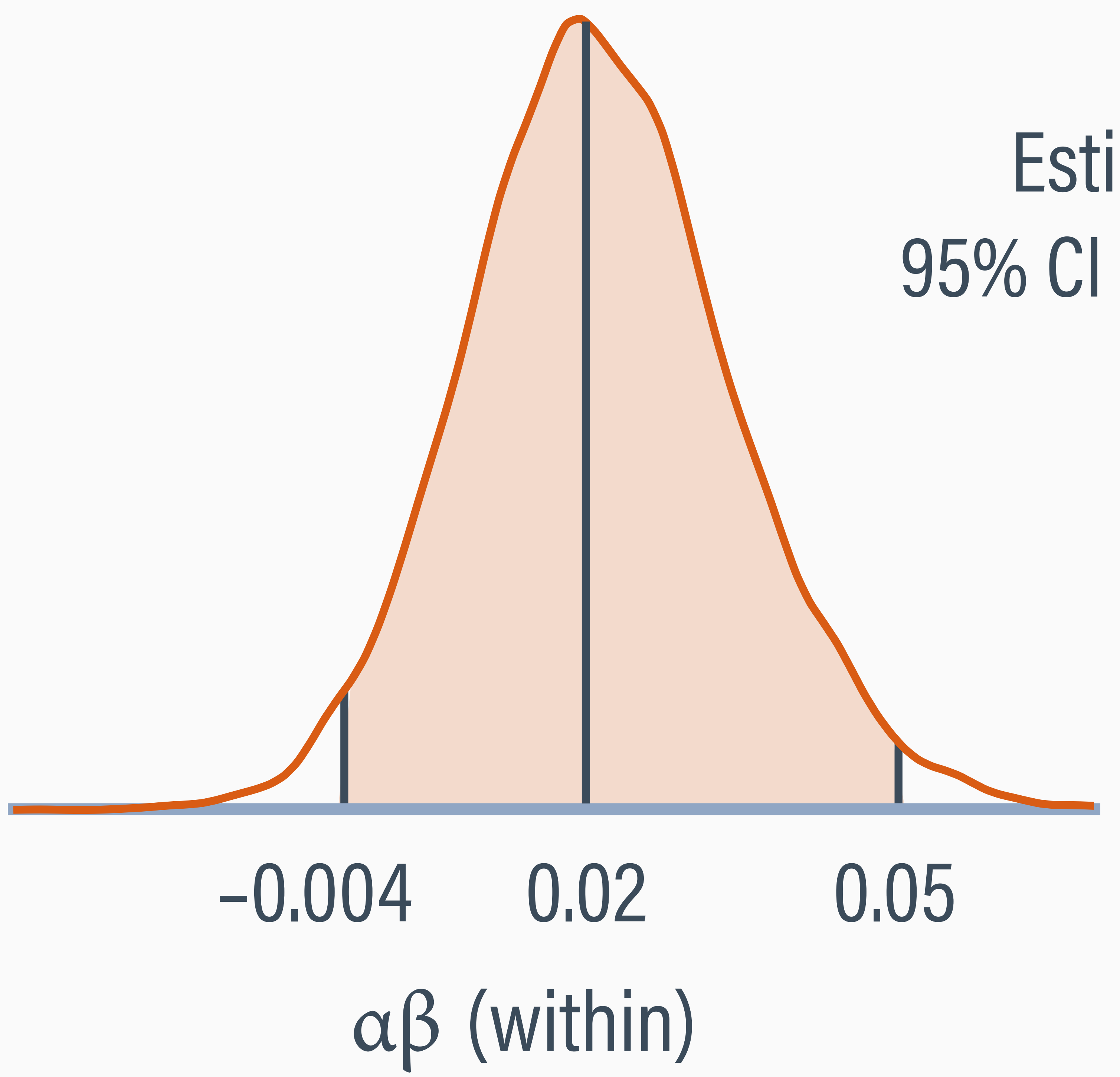
INTERPRETATIONS

- $\alpha^b = 0.005$ is the expected empowerment mean difference between two teams with average LMX values that differ by one point, controlling for team-average LMX

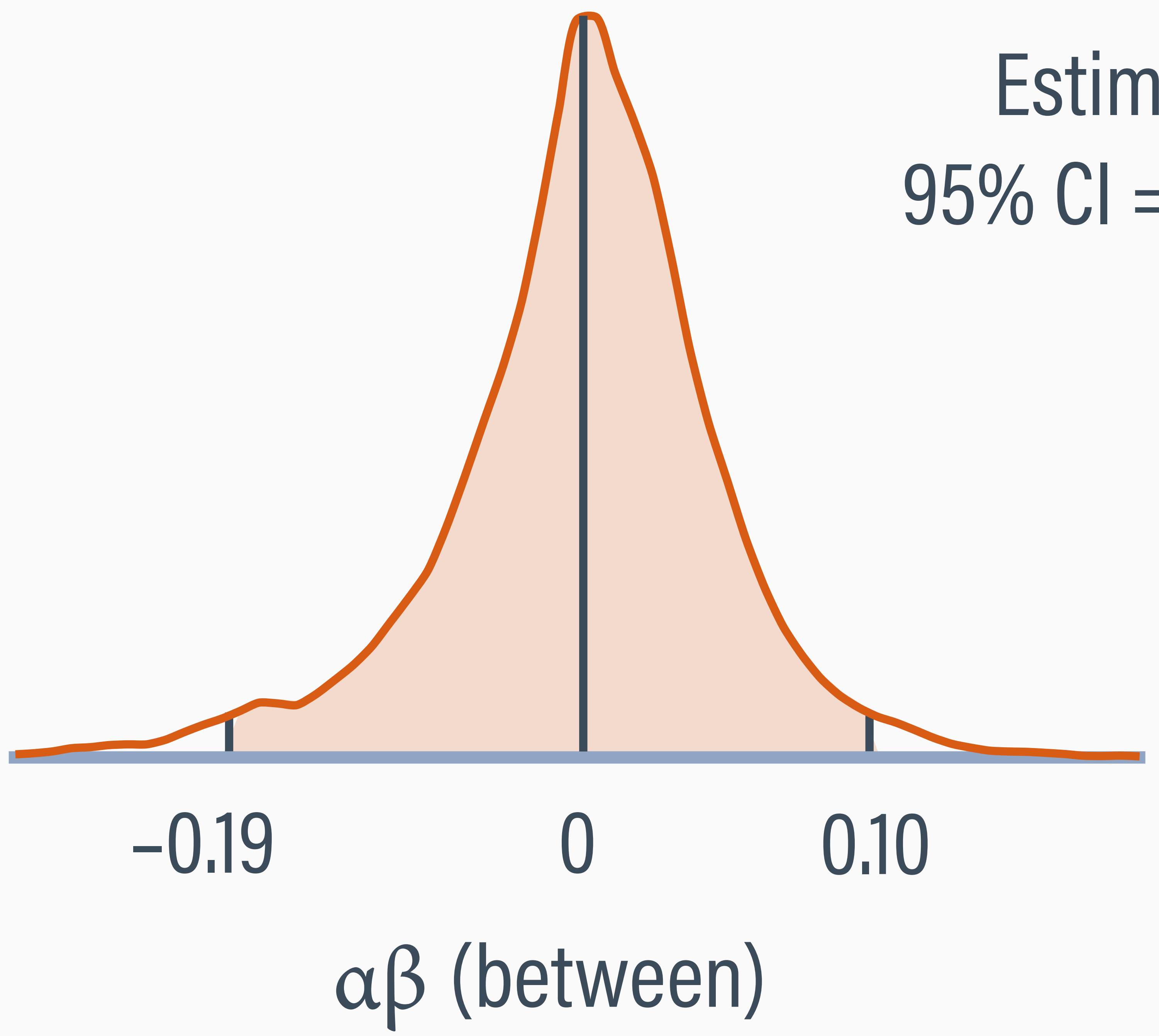
- $\beta^b = 0.17$ is the expected job satisfaction mean difference between two teams with average empowerment values that differ by one point, controlling for team-average LMX

DISTRIBUTIONS OF INDIRECT EFFECTS

- Indirect effects are computed at each MCMC iteration, producing a distribution of plausible mediated effects at each level



Estimate = 0.022
95% CI = (−0.004, 0.052)



Estimate = 0.001
95% CI = (−0.187 0.102)

INDIRECT EFFECTS OUTPUT

= level-2 estimate

= level-1 estimate

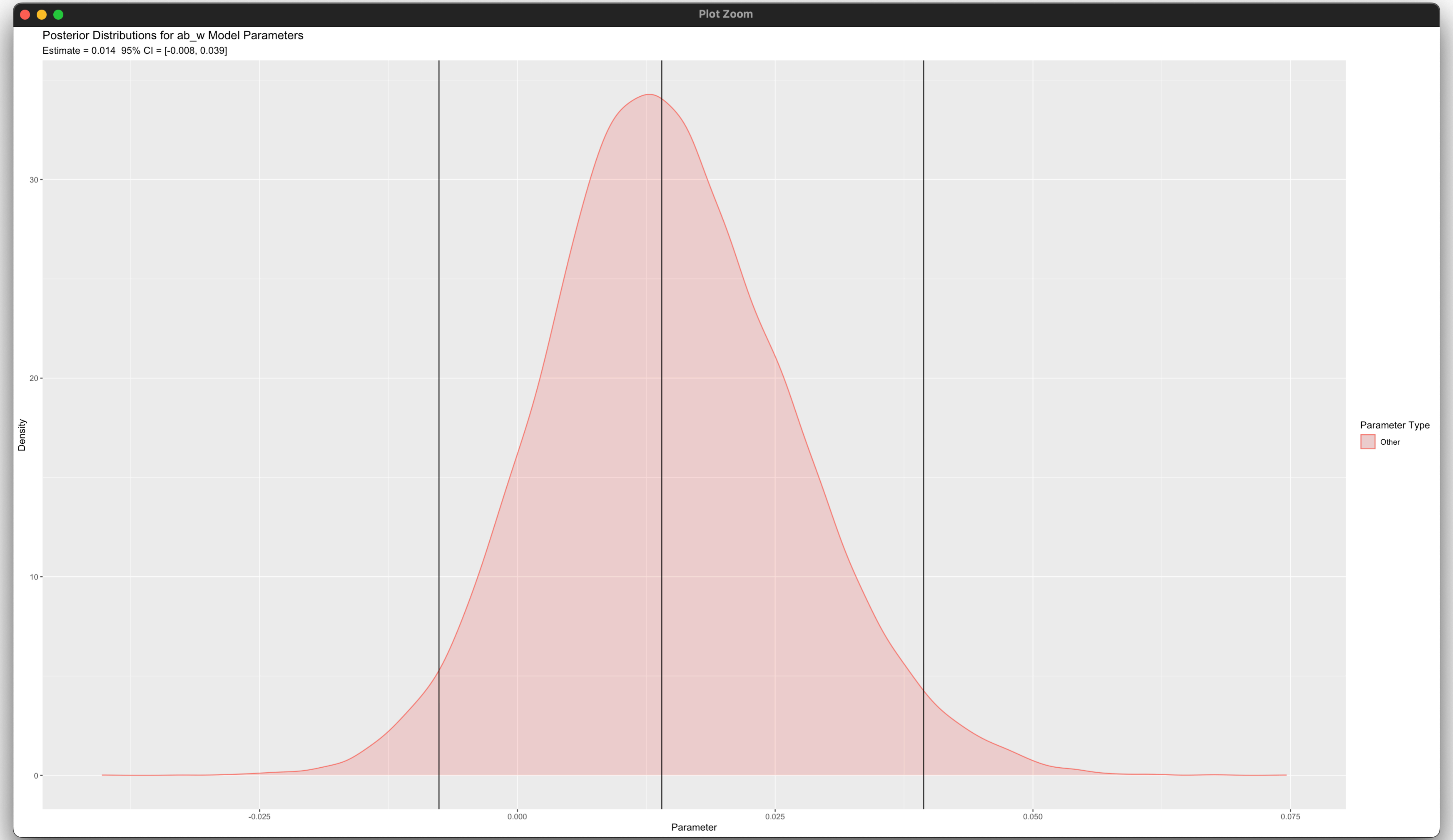
Standard test statistics are inappropriate for evaluating mediated effects!

GENERATED PARAMETERS:

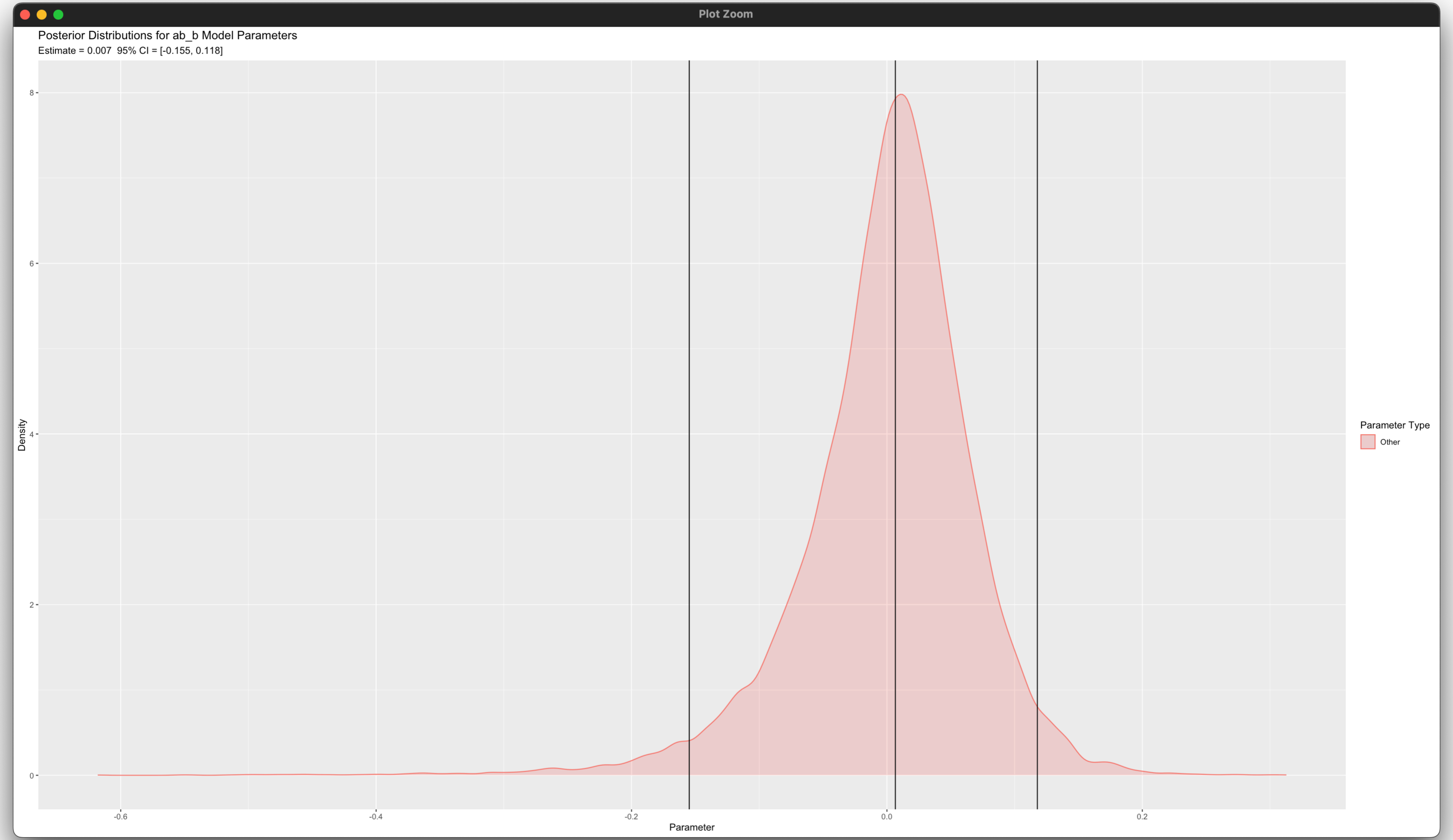
Summaries based on 20000 iterations using 2 chains.
NOTE: Estimate column based on posterior median.

Parameters	Estimate	StdDev	2.5%	97.5%	ChiSq	PValue	N_Eff
ab_cov	0.007	0.010	-0.012	0.027	0.4[illegible]	[illegible].494	320.266
ab_w	0.022	0.014	-0.004	0.052	2.[illegible]	[illegible].105	243.150
ab_b	0.001	0.073	-0.187	0.102	0.0[illegible]	[illegible].895	261.393

DISTRIBUTION OF $\alpha\beta^{w}$ (RBLIMP ONLY)



DISTRIBUTION OF $\alpha\beta^b$ (RBLIMP ONLY)

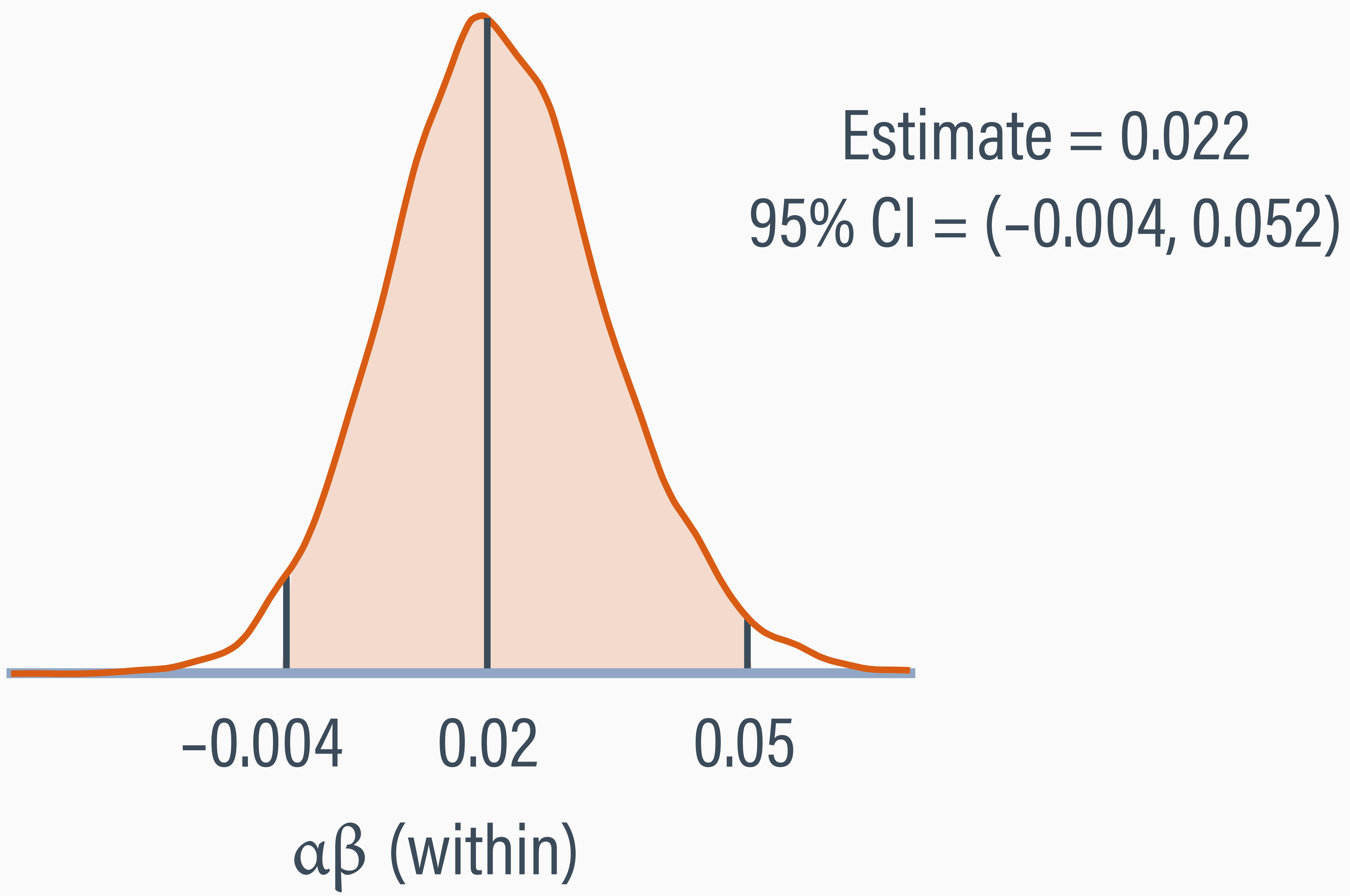


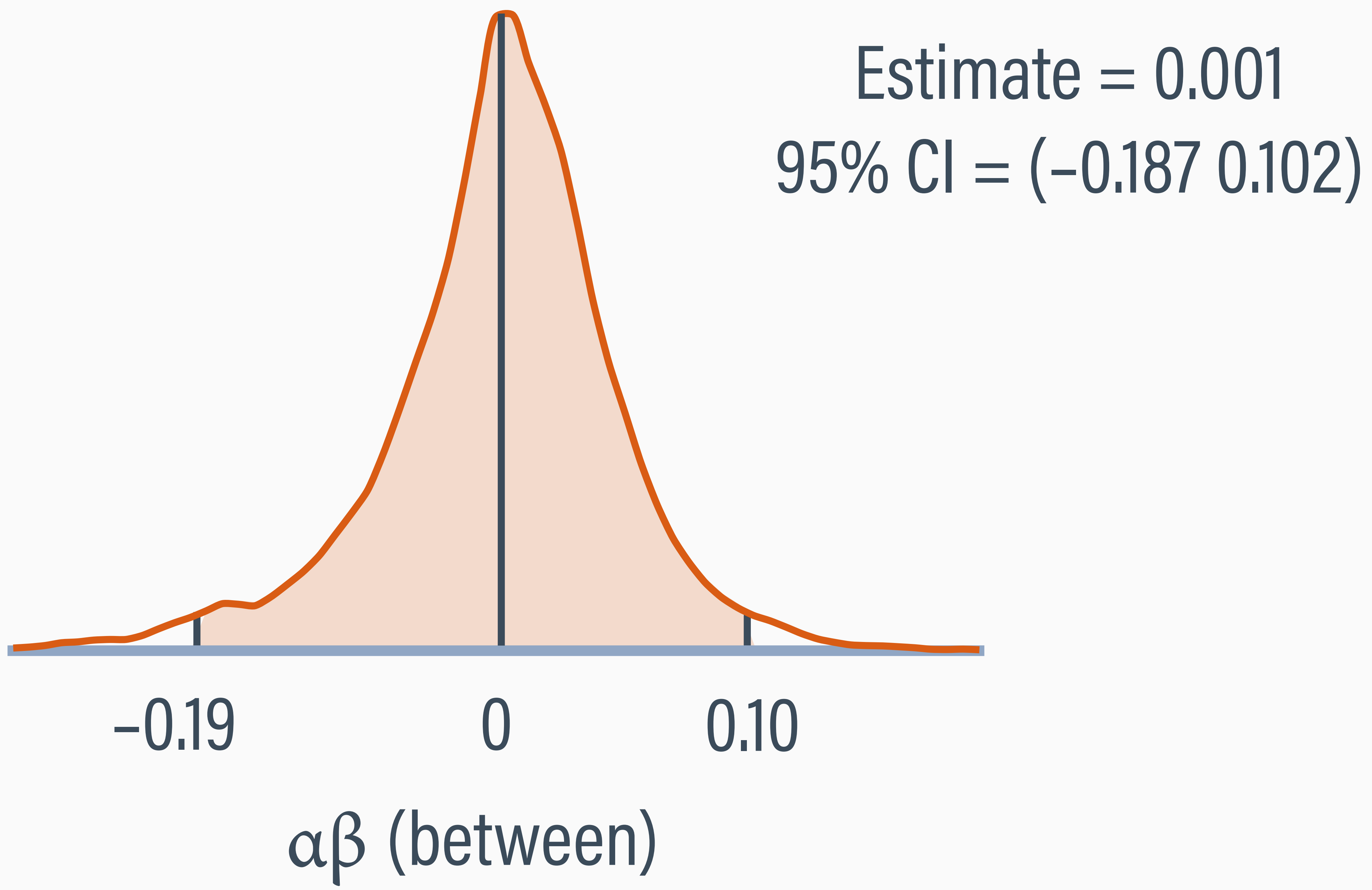
INTERPRETATIONS

- $\alpha\beta^{w} = .022$ is the effect of a one-point within-team difference on LMX that gets transmitted to job satisfaction via a one-point within-team difference in empowerment (the mediator)
- $\alpha\beta^{b} = 0.001$ is the effect of a one-point between-team mean difference on LMX that gets transmitted to job satisfaction via a one-point mean difference in empowerment (the mediator)

95% ASYMMETRIC INTERVALS

- Zero is inside both 95% intervals (just barely at level-1), implying that the data could have originated from a population with no mediation



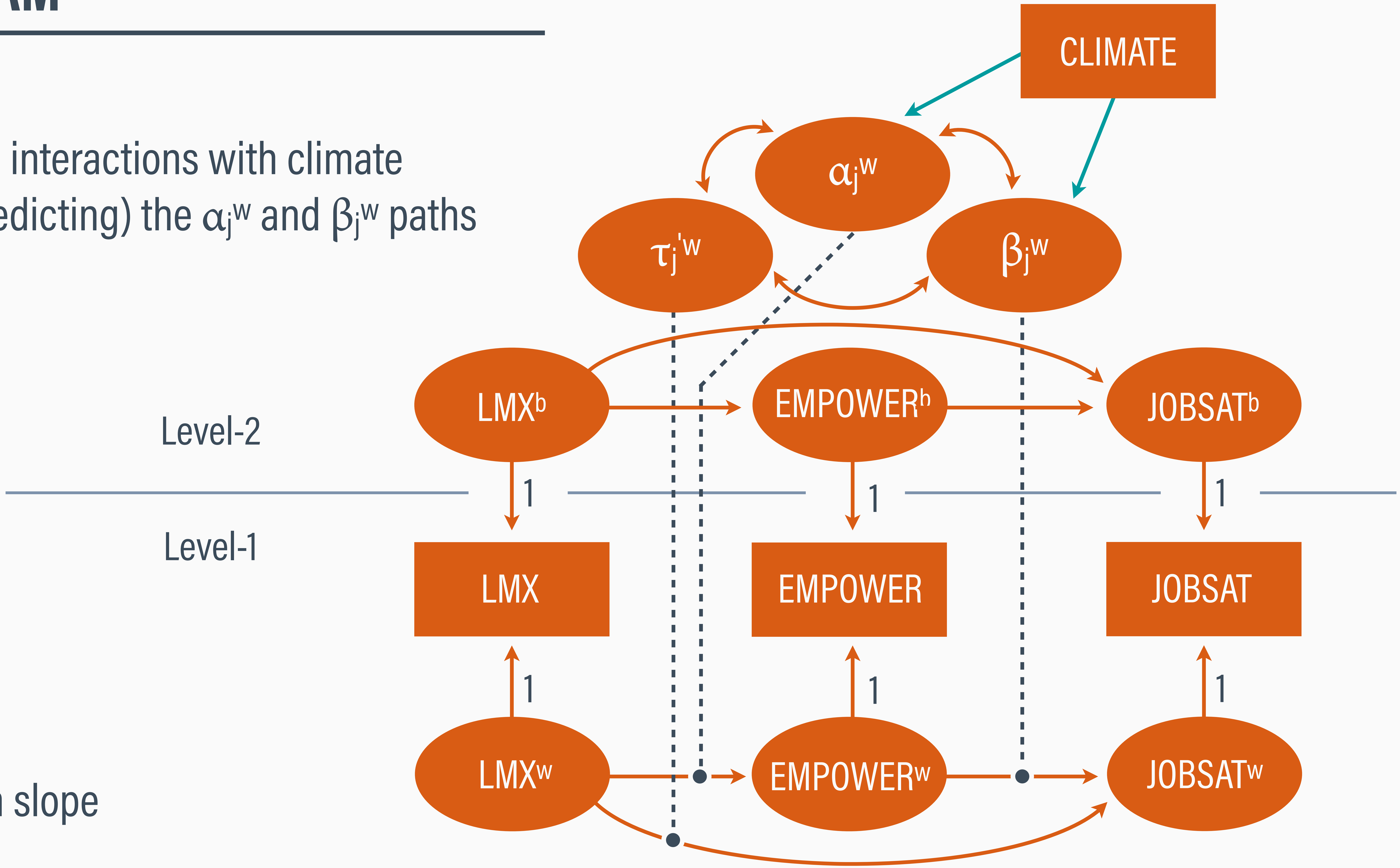


OUTLINE

1. Mediation Overview
2. 1–1–1 Model With Random Intercepts
3. 1–1–1 Model With Random Slopes
4. Moderation on the α or β paths

PATH DIAGRAM

Cross-level interactions with climate moderating (predicting) the α_j^w and β_j^w paths



• = random slope

BLIMP SCRIPT 7.3 EXCERPT

```
LATENT: Team = LMX_b Empower_b JobSat_b apath_w bpath_w tpath_w;
CENTER: grandmean = Climate;
MODEL:
...
level2:
Climate ~ intercept;
LMX_b ~ intercept;
Empower_b ~ intercept LMX_b@apath_b Climate;
JobSat_b ~ intercept LMX_b@tpath_b Empower_b@bpath_b Climate;
apath_w ~ intercept@apathw_mean climate@apathw_mod;   # random slope predicted by level-2 moderator
bpath_w ~ intercept@bpathw_mean climatebpathw_mod;   # random slope predicted by level-2 moderator
tpath_w ~ intercept;
apath_w ~~ bpath_w@ab_corr;   # correlate random a and b paths and attach a label;
apath_w bpath_w ~~ tpath_w;    # correlate remaining random slopes
...
```

BLIMP SCRIPT 7.3 EXCERPT

Conditional mediated effects and different values of the moderator (team-level climate)

PARAMETERS:

```
ab_cov = ab_corr * sqrt(apath_w.totalvar * bpath_w.totalvar);   # covariance between random slopes
a_hi = apathw_mean + apathw_mod*sqrt(climate.totalvar);   # a path at different values of the moderator
a_mean = apathw_mean;
a_lo = apathw_mean - apathw_mod*sqrt(climate.totalvar);
b_hi = bpathw_mean + bpathw_mod*sqrt(climate.totalvar);   # b path at different values of the moderator
b_mean = bpathw_mean;
b_lo = bpathw_mean - bpathw_mod*sqrt(climate.totalvar);
ab_w_hi = a_hi*b_hi + ab_cov;   # within-cluster mediated effect at different values of the moderator
ab_w_mean = a_mean*b_mean + ab_cov;
ab_w_lo = a_lo*b_lo + ab_cov;
ab_b = apath_b*bpath_b;   # between-cluster mediated effect
```

INDIRECT EFFECTS OUTPUT

= level-2 estimate

= level-1 estimate

GENERATED PARAMETERS:

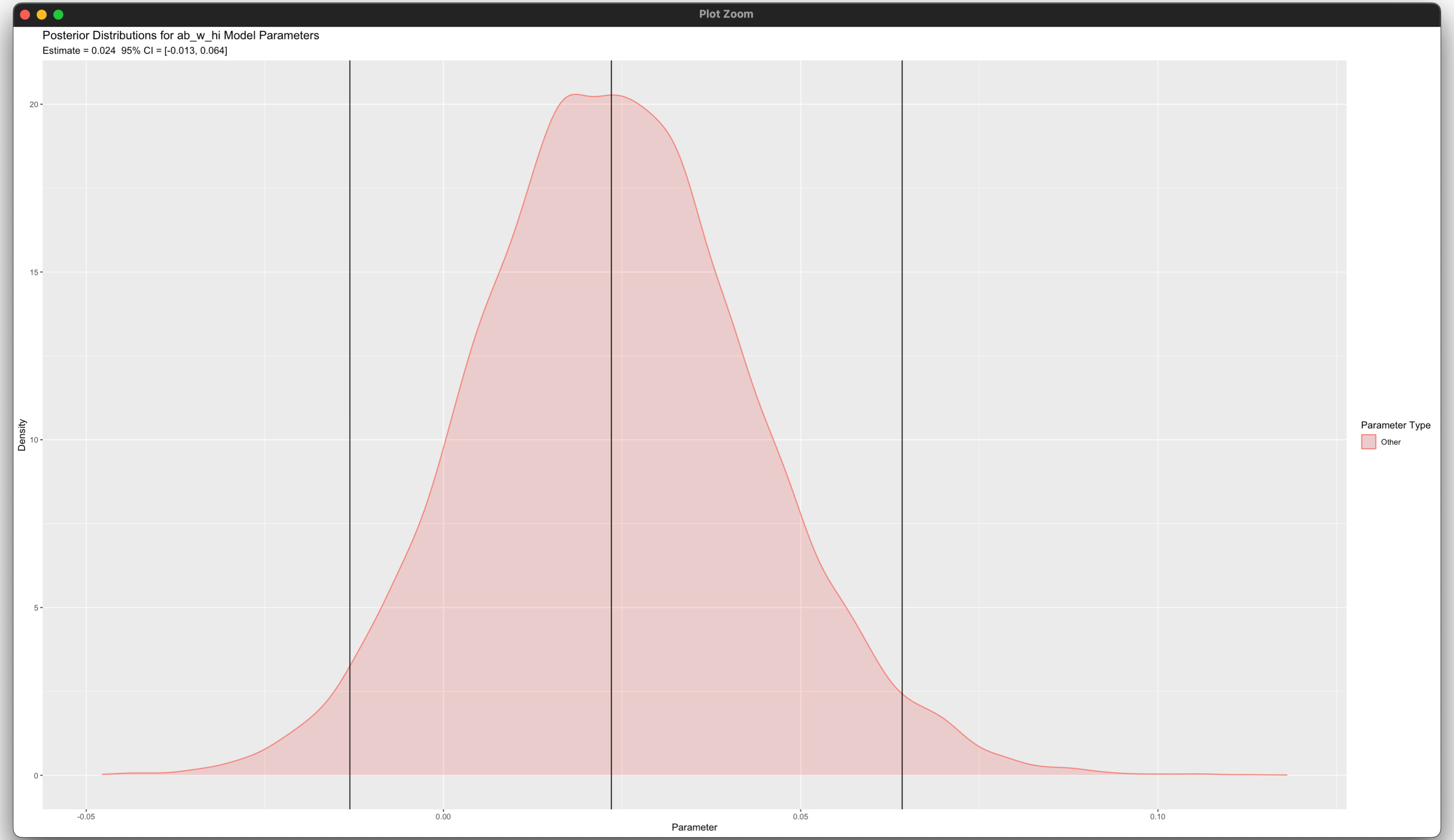
Summaries based on 20000 iterations using 2 chains.
NOTE: Estimate column based on posterior median.

Standard test statistics are inappropriate for evaluating mediated effects!

Parameters	Estimate	StdDev	2.5%	97.5%	ChiSq	PValue	N_Eff
ab_cov	0.008	0.010	-0.012	0.028	0.651	0.420	526.299
a_hi	0.849	0.103	0.651	1.053	67.974	0.000	723.826
a_mean	0.655	0.073	0.510	0.797	80.705	0.000	830.976
a_lo	0.462	0.104	0.254	0.663	19.685	0.000	863.252
b_hi	0.019	0.019	-0.018	0.058	0.9[illegible]	[illegible].341	311.687
b_mean	0.025	0.016	-0.004	0.058	2.7[illegible]	[illegible].096	359.128
b_lo	0.033	0.020	-0.005	0.073	2.6[illegible]	[illegible].103	566.367
ab_w_hi	**0.024**	0.020	**-0.013**	**0.064**	1.505	0.220	463.559
ab_w_mean	**0.025**	0.015	**-0.003**	**0.055**	2.930	0.087	494.087
ab_w_lo	**0.023**	0.015	**-0.004**	**0.054**	2.577	0.108	539.407
ab_b	**0.008**	0.066	**-0.158**	**0.108**	0.000	0.991	513.172

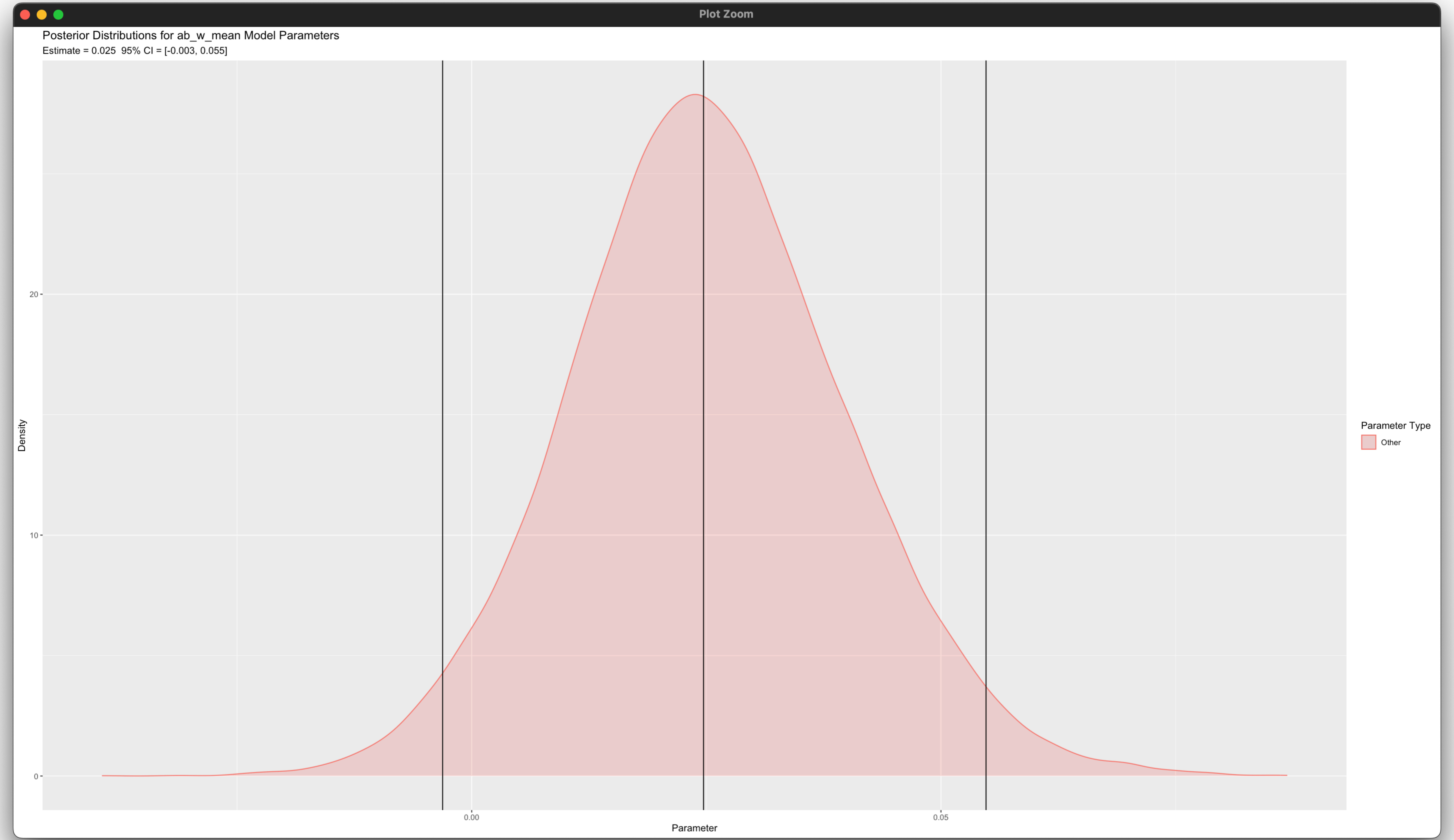
DISTRIBUTION OF $\alpha\beta^{w}$ (RBLIMP ONLY)

Conditional mediated effect at +1 SD above team-level climate mean



DISTRIBUTION OF $\alpha\beta^{w}$ (RBLIMP ONLY)

Conditional mediated effect at the team-level climate mean



DISTRIBUTION OF $\alpha\beta^w$ (RBLIMP ONLY)

Conditional mediated effect at –1 SD above team-level climate mean