

metaSEM: Meta-Analysis using Structural Equation Modeling

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1 Introduction

`metaSEM` is an R package that conducts univariate and multivariate meta-analysis using structural equation modeling (SEM) approach (Cheung, 2008) via the `OpenMx` package. It also implements the two-stage structural equation modeling (TSSEM) approach (Cheung and Chan, 2005, 2009) to conducting meta-analytic structural equation modeling (MASEM) on correlation/covariance matrices. The main functions in this package are:

- `tssem1()`: It conducts the first stage analysis of TSSEM by pooling correlation/covariance matrices with a fixed-effects model.
- `tssem2()`: It conducts the second stage analysis of TSSEM by calling `wls()`.
- `wls()`: It fits a correlation/covariance structure analysis with weighted least squares.
- `meta()`: It conducts univariate and multivariate meta-analysis with maximum likelihood estimation method. Mixed-effects meta-analysis can be conducted by including study characteristics as predictors. Equality constraints on intercepts, regression coefficients and variance components can be easily imposed.

Besides reporting approximate confidence intervals (CIs) based on z statistic, it is also possible to request likelihood-based CIs on the parameter estimates (Cheung, 2009a; Neale and Miller, 1997).

The current version is 0.5-2. Please send any bugs and comments to me at <mikewlcheung (at) nus.edu.sg>.

2 Installation

First of all, you need R to run it. Since metaSEM uses OpenMx as the workhorse, OpenMx has also to be installed. To install OpenMx, run the following command inside an R session:

```
source('http://openmx.psyc.virginia.edu/getOpenMx.R')
```

See <http://openmx.psyc.virginia.edu/installing-openmx> for the details on how to install OpenMx. If you are using Fedora and have problems in installing OpenMx, you may refer to the following [post](#).

2.1 Windows platform

Download the [Windows binary](#) of metaSEM. If the file is saved at d:\. Run the following command inside an R session:

```
install.packages(pkgs="d:/metaSEM_0.5-2.zip", repos=NULL)
```

Please note that d:\ in Windows is represented by either d:/ or d:\\ in R.

2.2 Linux platform

Download the [source package](#) of metaSEM. Run the following command as Root in a terminal:

```
R CMD INSTALL metaSEM_0.5-2.tar.gz
```

3 Examples

3.1 Two-stage SEM

An example on two-stage structural equation modeling (TSSEM) from [Cheung \(2009b\)](#):

```
> library(metaSEM)
> ## Sample correlation matrices with missing values
> Cheung09$data

$`1`
      x1      x2      x3      x4      x5      x6      x7      x8      x9
x1 0.77298 0.26975 0.24009 0.23778 0.20869 0.22377 0.18801 0.07055 0.10051
x2 0.26975 0.91307 0.44374 0.26083 0.28387 0.20660 0.12764 0.22892 0.09590
x3 0.24009 0.44374 1.11292 0.29440 0.26262 0.27320 0.18548 0.20417 0.18243
x4 0.23778 0.26083 0.29440 0.80501 0.47489 0.45939 0.40998 0.09104 0.10142
x5 0.20869 0.28387 0.26262 0.47489 0.89692 0.41972 0.31541 0.33907 0.06561
x6 0.22377 0.20660 0.27320 0.45939 0.41972 1.36089 0.74274 0.18137 0.12973
x7 0.18801 0.12764 0.18548 0.40998 0.31541 0.74274 1.01075 0.13724 0.12776
```

```
x8 0.07055 0.22892 0.20417 0.09104 0.33907 0.18137 0.13724 1.81805 -0.01980
x9 0.10051 0.09590 0.18243 0.10142 0.06561 0.12973 0.12776 -0.01980 0.91252
```

```
$`2`
```

	x1	x2	x3	x4	x5	x6	x7	x8	x9
x1	NA	NA	NA	NA	NA	NA	NA	NA	NA
x2	NA	NA	NA	NA	NA	NA	NA	NA	NA
x3	NA	NA	1.06293	0.27094	0.20331	0.16522	0.11922	0.25387	0.06877
x4	NA	NA	0.27094	0.73625	0.27053	0.33506	0.33495	0.16124	0.00912
x5	NA	NA	0.20331	0.27053	0.71718	0.19873	0.14582	0.21907	0.04089
x6	NA	NA	0.16522	0.33506	0.19873	0.92247	0.55128	0.17143	0.01380
x7	NA	NA	0.11922	0.33495	0.14582	0.55128	1.00462	0.16561	0.04322
x8	NA	NA	0.25387	0.16124	0.21907	0.17143	0.16561	1.49431	0.29094
x9	NA	NA	0.06877	0.00912	0.04089	0.01380	0.04322	0.29094	1.01960

```
$`3`
```

	x1	x2	x3	x4	x5	x6	x7	x8	x9
x1	0.95825	0.32958	NA	NA	NA	0.13948	0.15463	0.15248	0.10405
x2	0.32958	1.02277	NA	NA	NA	0.07300	0.07002	0.17056	0.13502
x3	NA	NA	NA	NA	NA	NA	NA	NA	NA
x4	NA	NA	NA	NA	NA	NA	NA	NA	NA
x5	NA	NA	NA	NA	NA	NA	NA	NA	NA
x6	0.13948	0.07300	NA	NA	NA	0.82987	0.43769	0.23195	0.03856
x7	0.15463	0.07002	NA	NA	NA	0.43769	0.83476	0.19002	0.03986
x8	0.15248	0.17056	NA	NA	NA	0.23195	0.19002	1.42583	0.38343
x9	0.10405	0.13502	NA	NA	NA	0.03856	0.03986	0.38343	1.03062

```
$`4`
```

	x1	x2	x3	x4	x5	x6	x7	x8	x9
x1	0.83995	0.21117	0.14249	0.13268	0.17861	0.22783	0.18991	NA	NA
x2	0.21117	0.93380	0.34383	0.19040	0.15068	0.12191	-0.04762	NA	NA
x3	0.14249	0.34383	1.33025	0.31041	0.10873	0.19756	0.12113	NA	NA
x4	0.13268	0.19040	0.31041	0.77512	0.36093	0.36519	0.22716	NA	NA
x5	0.17861	0.15068	0.10873	0.36093	0.91598	0.37035	0.19550	NA	NA
x6	0.22783	0.12191	0.19756	0.36519	0.37035	1.48445	0.62637	NA	NA
x7	0.18991	-0.04762	0.12113	0.22716	0.19550	0.62637	1.05049	NA	NA
x8	NA	NA	NA	NA	NA	NA	NA	NA	NA
x9	NA	NA	NA	NA	NA	NA	NA	NA	NA

```
> ## Sample sizes
```

```
> Cheung09$n
```

```
[1] 591 656 832 823
```

```
> ## Stage 1: Analysis of correlation matrices
```

```
> ## A pooled correlation matrix will be estimated.
```

```
> ## tssem1() is the function for stage 1 analysis.
> cor1 <- tssem1(Cheung09$data, Cheung09$n)
```

Running TSSEM1 Analysis of Correlation Matrix

```
> summary(cor1)
```

Call:

```
tssem1(my.df = Cheung09$data, n = Cheung09$n)
```

Coefficients:

	Estimate	Std.Error	z value	Pr(> z)	
S1[1,2]	0.295204	0.019261	15.3267	< 2.2e-16	***
S1[1,3]	0.195314	0.024753	7.8906	3.109e-15	***
S1[1,4]	0.218765	0.024123	9.0687	< 2.2e-16	***
S1[1,5]	0.219892	0.024410	9.0082	< 2.2e-16	***
S1[1,6]	0.188085	0.020244	9.2910	< 2.2e-16	***
S1[1,7]	0.192202	0.020246	9.4935	< 2.2e-16	***
S1[1,8]	0.098346	0.025657	3.8331	0.0001265	***
S1[1,9]	0.098793	0.025907	3.8134	0.0001371	***
S1[2,3]	0.369539	0.022701	16.2786	< 2.2e-16	***
S1[2,4]	0.254045	0.023529	10.7971	< 2.2e-16	***
S1[2,5]	0.228516	0.024102	9.4813	< 2.2e-16	***
S1[2,6]	0.114146	0.020524	5.5617	2.672e-08	***
S1[2,7]	0.045226	0.020796	2.1747	0.0296520	*
S1[2,8]	0.148063	0.025249	5.8640	4.517e-09	***
S1[2,9]	0.101851	0.025717	3.9605	7.479e-05	***
S1[3,4]	0.307685	0.019829	15.5172	< 2.2e-16	***
S1[3,5]	0.190536	0.021200	8.9877	< 2.2e-16	***
S1[3,6]	0.168642	0.020895	8.0710	6.661e-16	***
S1[3,7]	0.131197	0.021077	6.2246	4.827e-10	***
S1[3,8]	0.165582	0.027014	6.1294	8.819e-10	***
S1[3,9]	0.125626	0.027583	4.5545	5.251e-06	***
S1[4,5]	0.451817	0.017509	25.8050	< 2.2e-16	***
S1[4,6]	0.385261	0.018402	20.9362	< 2.2e-16	***
S1[4,7]	0.356265	0.018830	18.9201	< 2.2e-16	***
S1[4,8]	0.118677	0.026683	4.4477	8.681e-06	***
S1[4,9]	0.056840	0.027195	2.0901	0.0366073	*
S1[5,6]	0.312551	0.019537	15.9978	< 2.2e-16	***
S1[5,7]	0.231882	0.020370	11.3833	< 2.2e-16	***
S1[5,8]	0.238514	0.026160	9.1175	< 2.2e-16	***
S1[5,9]	0.064726	0.027417	2.3608	0.0182349	*
S1[6,7]	0.553723	0.012912	42.8834	< 2.2e-16	***
S1[6,8]	0.162009	0.021035	7.7018	1.332e-14	***
S1[6,9]	0.053050	0.021659	2.4493	0.0143139	*
S1[7,8]	0.135426	0.021212	6.3844	1.720e-10	***
S1[7,9]	0.066476	0.021651	3.0704	0.0021377	**

```
S1[8,9] 0.198066 0.021254 9.3191 < 2.2e-16 ***
```

```
---
```

```
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Goodness-of-fit indices:
```

	Value
Sample size	2902.0000
Chi-square of target model	172.7320
DF of target model	57.0000
p value of target model	0.0000
Chi-square of independent model	3246.6915
DF of independent model	93.0000
RMSEA	0.0529
SRMR	0.0549
TLI	0.9401
CFI	0.9633
AIC	58.7320
BIC	-281.7379

```
R version: 2.12.0
```

```
OpenMx version: 1.0.3-1505
```

```
metaSEM version: 0.5-2
```

```
Date of analysis: Sat Dec 11 16:15:43 2010
```

```
OpenMx status1: 0 ("0" and "1": considered fine; other values indicate problems)
```

```
See http://openmx.psyc.virginia.edu/wiki/errors for the details.
```

```
> ## Stage 2: Fit a three-factor CFA model on the pooled correlation matrix
> ## See http://openmx.psyc.virginia.edu/documentation on the OpenMx syntax
> P4 <- mxMatrix("Stand", ncol=3, nrow=3, value=.2, free=TRUE, name="P4")
> L4 <- mxMatrix("Full", ncol=3, nrow=9, value=c( rep(c(0.3,0,0),3),
+         rep(c(0, 0.3,0),4), rep(c(0,0,0.3),2)),
+         free=c( rep(c(T,F,F),3), rep(c(F,T,F),4),
+         rep(c(F,F,T),2)), byrow=TRUE, name="L4")
> ## impliedR = L4 %*% P4 %*% t(L4)
> impliedR4 <- mxAlgebra(L4 %&% P4, name="impliedR4")
> ## tssem2() is the function for stage 2 analysis.
> cor2 <- tssem2(cor1, impliedS=impliedR4, matrices=c(P4, L4))
```

```
Running Correlation structure
```

```
> summary(cor2)
```

```
Call:
```

```
wls(S = tssem1.obj$pooledS, acovS = tssem1.obj$acovS, n = tssem1.obj$total.n,
    impliedS = impliedS, matrices = matrices, cor.analysis = cor.analysis,
    intervals.type = intervals.type, suppressWarnings = suppressWarnings)
```

95% confidence intervals: z statistic approximation

Coefficients:

	Estimate	Std.Error	lbound	ubound	z value	Pr(> z)
L4[1,1]	0.517061	0.023568	0.470869	0.563254	21.9389	< 2.2e-16 ***
L4[2,1]	0.575072	0.023120	0.529758	0.620387	24.8734	< 2.2e-16 ***
L4[3,1]	0.593858	0.025586	0.543711	0.644004	23.2106	< 2.2e-16 ***
L4[4,2]	0.705138	0.014698	0.676330	0.733946	47.9750	< 2.2e-16 ***
L4[5,2]	0.579019	0.016902	0.545892	0.612146	34.2580	< 2.2e-16 ***
L4[6,2]	0.746403	0.013060	0.720806	0.772000	57.1515	< 2.2e-16 ***
L4[7,2]	0.692214	0.013622	0.665515	0.718912	50.8157	< 2.2e-16 ***
L4[8,3]	0.621998	0.052462	0.519175	0.724822	11.8561	< 2.2e-16 ***
L4[9,3]	0.332553	0.032670	0.268521	0.396584	10.1792	< 2.2e-16 ***
P4[1,2]	0.544769	0.025617	0.494560	0.594977	21.2659	< 2.2e-16 ***
P4[1,3]	0.488471	0.055862	0.378984	0.597958	8.7443	< 2.2e-16 ***
P4[2,3]	0.392611	0.040345	0.313536	0.471685	9.7314	< 2.2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Goodness-of-fit indices:

	Value
Sample size	2902.0000
Chi-square of target model	384.9041
DF of target model	24.0000
p value of target model	0.0000
Chi-square of independent model	4636.5843
DF of independent model	36.0000
RMSEA	0.0720
SRMR	0.0729
TLI	0.8823
CFI	0.9216
AIC	336.9041
BIC	193.5484

R version: 2.12.0

OpenMx version: 1.0.3-1505

metaSEM version: 0.5-2

Date of analysis: Sat Dec 11 16:15:44 2010

OpenMx status1: 0 ("0" and "1": considered fine; other values indicate problems)

See <http://openmx.psyc.virginia.edu/wiki/errors> for the details.

3.2 Reading External Data Files

Data sets are most likely stored externally. **metaSEM** reads three types of formats. The first type is full correlation/covariance matrices, for example, [fullmat.dat](#) is the same as the built-in data set **Cheung09**. Missing values are represented by NA (the default option). Suppose you save it at d:\fullmat.dat, you may read it

by using the following command in R:

```
my.df <- readFullMat(file="d:/fullmat.dat")
```

The second type is lower triangle correlation/covariance matrices, for example, [lowertriangle.dat](#). Missing values are represented by the strings 1.00000 and 0.00000. Suppose you save it at d:\lowertriangle.dat, you may read it by using the following command in R:

```
my.df <- readLowTriMat(file = "d:/lowertriangle.dat", no.var = 9,  
  na.strings=c("1.00000", "0.00000"))
```

The third type is vectors of correlation/covariance elements based on column vectorization. One row is for one study, for example, [stackvec.dat](#). Suppose you save it at d:\stackvec.dat, you may read it by using the following R command:

```
my2 <- readStackVec(file="d:/stackvec.dat")
```

3.3 Analysis of Correlation/Covariance Structure with Weighted Least Squares

Besides fitting a TSSEM, `wls()` may be used to fit a correlation/covariance structure with weighted least squares as the estimation method. Likelihood-based CIs may also be calculated. The following is an example.

```
> R1 <- matrix(c(1.00, 0.22, 0.24, 0.18,  
+               0.22, 1.00, 0.30, 0.22,  
+               0.24, 0.30, 1.00, 0.24,  
+               0.18, 0.22, 0.24, 1.00), ncol=4, nrow=4)  
> ## Sample size  
> n <- 1000  
> ## Calculate the asymptotic covariance matrix of the sample correlation matrix  
> acovR <- asyCov(R1, n)  
> ## P1: Factor variance  
> P1 <- mxMatrix("Full", ncol=1, nrow=1, value=1, free=FALSE, name="P1")  
> ## L1: Factor loadings  
> L1 <- mxMatrix("Full", ncol=1, nrow=4, value=c(0.3, 0.4, 0.5, 0.4),  
+               free=TRUE, name="L1")  
> ## Model implied correlation matrix  
> ## Please note that error variances are not involved in correlation structure analysis  
> impliedR1 <- mxAlgebra(L1 %&% P1, name="impliedR1")  
> ## wls() is the function to fitting correlation/covariance structure with WLS  
> wls.fit1 <- wls(S=R1, acovS=acovR, n=n, impliedS=impliedR1,  
+               matrices=c(P1, L1), cor.analysis=TRUE, intervals.type="LB")
```

Running Correlation structure

```
> summary(wls.fit1)
```

```
Call:
wls(S = R1, acovS = acovR, n = n, impliedS = impliedR1, matrices = c(P1,
  L1), cor.analysis = TRUE, intervals.type = "LB")
```

95% confidence intervals: Likelihood-based statistic

Coefficients:

	Estimate	Std.Error	lbound	ubound	z value	Pr(> z)
L1[1,1]	0.421592	0.038727	0.346320	0.498692	10.886	< 2.2e-16 ***
L1[2,1]	0.523764	0.039257	0.448295	0.603091	13.342	< 2.2e-16 ***
L1[3,1]	0.570921	0.040144	0.494310	0.652919	14.222	< 2.2e-16 ***
L1[4,1]	0.421592	0.038727	0.346326	0.498692	10.886	< 2.2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Goodness-of-fit indices:

	Value
Sample size	1000.0000
Chi-square of target model	0.0134
DF of target model	2.0000
p value of target model	0.9933
Chi-square of independent model	243.9807
DF of independent model	6.0000
RMSEA	0.0000
SRMR	0.0012
TLI	1.0250
CFI	1.0000
AIC	-3.9866
BIC	-13.8021

R version: 2.12.0

OpenMx version: 1.0.3-1505

metaSEM version: 0.5-2

Date of analysis: Sat Dec 11 16:15:44 2010

OpenMx status1: 0 ("0" and "1": considered fine; other values indicate problems)

See <http://openmx.psyc.virginia.edu/wiki/errors> for the details.

3.4 Univariate and Multivariate Meta-Analysis

Another useful function is `meta()`. It conducts fixed-, random-, and mixed-effects univariate and multivariate meta-analysis. The followings are some examples.

```
> attach(Hox02)
> summary( meta(y=yi, v=vi) )
```

Running Meta analysis

Call:


```
meta(y = yi, v = vi)
```

95% confidence intervals: z statistic approximation

Coefficients:

	Estimate	Std.Error	lbound	ubound	z value	Pr(> z)
Intercept1	0.579035	0.105100	0.373042	0.785028	5.5093	3.602e-08 ***
Tau1_1	0.131520	0.073536	-0.012608	0.275648	1.7885	0.0737 .

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Q statistic on homogeneity of effect sizes: 49.5852

Degrees of freedom of the Q statistic: 19

P value of the Q statistic: 0.0001508010

Number of studies: 20

Number of observed statistics: 20

Number of parameter estimated: 2

Degrees of freedom: 18

-2 log likelihood: 27.79916

R version: 2.12.0

OpenMx version: 1.0.3-1505

metaSEM version: 0.5-2

Date of analysis: Sat Dec 11 16:15:45 2010

OpenMx status1: 1 ("0" and "1": considered fine; other values indicate problems)

See <http://openmx.psyc.virginia.edu/wiki/errors> for the details.

```
> ## Fixed-effects meta-analysis
```

```
> summary( meta(y=yi, v=vi, RE.constraints=matrix(0, ncol=1, nrow=1)) )
```

Running Meta analysis

Call:

```
meta(y = yi, v = vi, RE.constraints = matrix(0, ncol = 1, nrow = 1))
```

95% confidence intervals: z statistic approximation

Coefficients:

	Estimate	Std.Error	lbound	ubound	z value	Pr(> z)
Intercept1	0.550206	0.064998	0.422813	0.677599	8.465	< 2.2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Q statistic on homogeneity of effect sizes: 49.5852

Degrees of freedom of the Q statistic: 19

P value of the Q statistic: 0.0001508010

Number of studies: 20

Number of observed statistics: 20
 Number of parameter estimated: 1
 Degrees of freedom: 19
 -2 log likelihood: 37.70073

R version: 2.12.0
 OpenMx version: 1.0.3-1505
 metaSEM version: 0.5-2
 Date of analysis: Sat Dec 11 16:15:45 2010
 OpenMx status1: 1 ("0" and "1": considered fine; other values indicate problems)
 See <http://openmx.psyc.virginia.edu/wiki/errors> for the details.

```
> ## Mixed-effects meta-analysis with "weeks" as the predictor
> ## Use likelihood-based CI
> summary( meta(y=yi, v=vi, x=weeks, intervals.type="LB") )
```

Running Meta analysis

Call:

```
meta(y = yi, v = vi, x = weeks, intervals.type = "LB")
```

95% confidence intervals: Likelihood-based statistic

Coefficients:

	Estimate	Std.Error	lbound	ubound	z value	Pr(> z)
Slope1_1	1.3866e-01	3.2089e-02	7.4635e-02	2.0695e-01	4.3210	1.553e-05
Intercept1	-2.1356e-01	1.9284e-01	-6.1977e-01	1.8104e-01	-1.1075	0.2681
Tau1_1	2.3252e-02	3.5481e-02	1.0000e-10	1.3790e-01	0.6553	0.5123

Slope1_1 ***

Intercept1

Tau1_1

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Q statistic on homogeneity of effect sizes: 49.5852

Degrees of freedom of the Q statistic: 19

P value of the Q statistic: 0.0001508010

Number of studies: 20
 Number of observed statistics: 40
 Number of parameter estimated: 5
 Degrees of freedom: 35
 -2 log likelihood: 104.9018

R version: 2.12.0
 OpenMx version: 1.0.3-1505
 metaSEM version: 0.5-2

Date of analysis: Sat Dec 11 16:15:46 2010
 OpenMx status1: 0 ("0" and "1": considered fine; other values indicate problems)
 See <http://openmx.psyc.virginia.edu/wiki/errors> for the details.

```
> detach(Hox02)
> ## Multivariate meta-analysis
> attach(Berkey98)
> summary( meta(y=cbind(PD, AL), v=cbind(var_PD, cov_PD_AL, var_AL)) )
```

Running Meta analysis

Call:

```
meta(y = cbind(PD, AL), v = cbind(var_PD, cov_PD_AL, var_AL))
```

95% confidence intervals: z statistic approximation

Coefficients:

	Estimate	Std.Error	lbound	ubound	z value	Pr(> z)
Intercept1	0.3448392	0.0536312	0.2397239	0.4499544	6.4298	1.278e-10 ***
Intercept2	-0.3379381	0.0812479	-0.4971812	-0.1786951	-4.1593	3.192e-05 ***
Tau1_1	0.0070020	0.0090497	-0.0107351	0.0247391	0.7737	0.4391
Tau2_1	0.0094607	0.0099698	-0.0100797	0.0290010	0.9489	0.3427
Tau2_2	0.0261445	0.0177409	-0.0086270	0.0609161	1.4737	0.1406

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Q statistic on homogeneity of effect sizes: 128.2267

Degrees of freedom of the Q statistic: 8

P value of the Q statistic: 0

Number of studies: 5

Number of observed statistics: 10

Number of parameter estimated: 5

Degrees of freedom: 5

-2 log likelihood: -11.68131

R version: 2.12.0

OpenMx version: 1.0.3-1505

metaSEM version: 0.5-2

Date of analysis: Sat Dec 11 16:15:46 2010

OpenMx status1: 0 ("0" and "1": considered fine; other values indicate problems)

See <http://openmx.psyc.virginia.edu/wiki/errors> for the details.

```
> ## Multivariate meta-analysis with "publication year-1979" as the predictor
> summary( meta(y=cbind(PD, AL), v=cbind(var_PD, cov_PD_AL, var_AL),
+         x=scale(pub_year, center=1979)) )
```

Running Meta analysis

Call:

```
meta(y = cbind(PD, AL), v = cbind(var_PD, cov_PD_AL, var_AL),      x = scale(pub_year, center=1979))
```

95% confidence intervals: z statistic approximation

Coefficients:

	Estimate	Std.Error	lbound	ubound	z value	Pr(> z)
Slope1_1	0.0063540	0.1078235	-0.2049761	0.2176842	0.0589	0.95301
Slope2_1	-0.0705888	0.1620965	-0.3882921	0.2471146	-0.4355	0.66322
Intercept1	0.3440001	0.0857659	0.1759021	0.5120982	4.0109	6.048e-05 ***
Intercept2	-0.2918175	0.1312796	-0.5491208	-0.0345141	-2.2229	0.02622 *
Tau1_1	0.0080405	0.0101206	-0.0117955	0.0278766	0.7945	0.42692
Tau2_1	0.0093413	0.0105515	-0.0113392	0.0300218	0.8853	0.37599
Tau2_2	0.0250135	0.0170788	-0.0084603	0.0584873	1.4646	0.14303

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Q statistic on homogeneity of effect sizes: 128.2267

Degrees of freedom of the Q statistic: 8

P value of the Q statistic: 0

Number of studies: 5

Number of observed statistics: 15

Number of parameter estimated: 9

Degrees of freedom: 6

-2 log likelihood: -4.595466

R version: 2.12.0

OpenMx version: 1.0.3-1505

metaSEM version: 0.5-2

Date of analysis: Sat Dec 11 16:15:47 2010

OpenMx status1: 0 ("0" and "1": considered fine; other values indicate problems)

See <http://openmx.psyc.virginia.edu/wiki/errors> for the details.

```
> ## Multivariate meta-analysis with an equality constraint on the slopes
> summary( meta(y=cbind(PD, AL), v=cbind(var_PD, cov_PD_AL, var_AL),
+       x=scale(pub_year, center=1979),
+       coeff.constraints=
+       matrix(c("0.3*Eq_slope", "0.3*Eq_slope"), nrow=2)) )
```

Running Meta analysis

Call:

```
meta(y = cbind(PD, AL), v = cbind(var_PD, cov_PD_AL, var_AL),      x = scale(pub_year, center=1979))
```

95% confidence intervals: z statistic approximation

Coefficients:

	Estimate	Std.Error	lbound	ubound	z value	Pr(> z)
Eq_slope	0.0016748	0.1024443	-0.1991123	0.2024619	0.0163	0.986956

```

Intercept1  0.3437612  0.0849828  0.1771979  0.5103245  4.0451 5.231e-05 ***
Intercept2 -0.3390010  0.1041005 -0.5430344 -0.1349677 -3.2565 0.001128 **
Tau1_1      0.0070474  0.0094638 -0.0115013  0.0255962  0.7447 0.456471
Tau2_1      0.0095165  0.0105668 -0.0111940  0.0302269  0.9006 0.367800
Tau2_2      0.0261979  0.0180773 -0.0092330  0.0616288  1.4492 0.147278
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Q statistic on homogeneity of effect sizes: 128.2267
Degrees of freedom of the Q statistic: 8
P value of the Q statistic: 0

Number of studies: 5
Number of observed statistics: 15
Number of parameter estimated: 8
Degrees of freedom: 7
-2 log likelihood: -4.268456

R version: 2.12.0
OpenMx version: 1.0.3-1505
metaSEM version: 0.5-2
Date of analysis: Sat Dec 11 16:15:47 2010
OpenMx status1: 0 ("0" and "1": considered fine; other values indicate problems)
See http://openmx.psyc.virginia.edu/wiki/errors for the details.

> detach(Berkey98)

```

4 Acknowledgements

This package cannot be written without R and OpenMx. Contributions by the R Development Core Team and the OpenMx Core Development Team are highly appreciated.

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