OpenMx: An Open Source and Extensible SEM Framework

Steven Boker¹  Michael Neale²  Hermine Maes²  Paras Mehta³  Michael Wilde⁴  Timothy Brick¹  Jeffrey Spies¹  Michael Spiegel¹  Ryne Estabrook¹  Michael Hunter¹  Sarah Kenny⁴  John Fox⁵  Timothy Bates⁶

¹University of Virginia; ²Virginia Commonwealth University; ³University of Houston; ⁴University of Chicago, Argonne National Labs; ⁵McMasters University; ⁶University of Edinburgh

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Announcing the Open Beta Test of OpenMx

OpenMx is
1. A free, full–featured, open source SEM package.
2. Runs on Windows, Mac OS-X, and Linux.
3. Runs inside the R statistical programming environment.
4. Funded by the NIH Roadmap Initiative.

OpenMx features:
1. A new approach to model specification.
2. Allows both path-style and matrix-style scripting.
3. Flexible optimization including nonlinear constraints.
5. Support for most popular types of modeling.
6. Advanced features not found in other SEM packages.
7. An active development team.

http://openmx.psyc.virginia.edu
Why Open Source?

- Open source refers to a community-based approach to development of software.
- OpenMx is not a black box.
  - You can look at our code to see exactly how we calculate everything.
- OpenMx is built around the scientific model.
  - Acknowledgement of each other’s work.
  - Contribution of one’s own work to the benefit of all.
- We hope that OpenMx will provide quantitative graduate students a boost towards implementing their own ideas.
- You can use our code in your own projects!
  - Apache 2.0 License.
What Models Are Addressed?

- In the current beta version.
  - Multivariate Normal Structural Equation Models.
  - Multigroup Models, e.g. Behavior Genetic.
  - Full Information Maximum Likelihood.
  - Mixed Effects and Multilevel.
  - Multivariate Categorical Data with Thresholds.
  - Dynamical Systems Models.
  - Nonlinear Constraints.
  - User-supplied Matrix Algebra and Objective Functions.
  - Much, much more.

- Under development and coming soon.
  - Mixture Distribution Models.
  - Cross-Classified Multivariate Multilevel.
  - Multi-Chain Monte Carlo / Bayesian Estimation.
  - Grid-Enabled Parallelizing Estimation.
Path Model using Covariances

```r
require(OpenMx)
demoData <- read.table("demoOneFactor.dat")
manifests <- names(demoData)
latents <- c("G")
factorModel <- mxModel("One Factor", type="RAM",
  manifestVars = manifests, latentVars = latents,
  mxPath(from=latents, to=manifests),
  mxPath(from=manifests, arrows=2),
  mxPath(from=latents, arrows=2, free=F, values=1.0),
  mxData(cov(demoData), type="cov", numObs=dim(demoData)[1])
)
summary(mxRun(factorModel))
```
Matrix Model using Covariances

\[ R = A L A' + U \]

```r
require(OpenMx)
demoData <- read.table("demoOneFactor.dat")
manifests <- names(demoData)
factorModel <- mxModel("One Factor",
  mxMatrix("Full", 5, 1, values=0.2, free=T, name="A"),
  mxMatrix("Symm", 1, 1, values=1, free=F, name="L"),
  mxMatrix("Diag", 5, 5, values=1, free=T, name="U"),
  mxAlgebra(A %*% L %*% t(A) + U,
            name="R",
            dimnames = list(manifests, manifests)
  ),
  mxMLObjective("R"),
  mxData(cov(demoData), type="cov", numObs=dim(demoData)[1])
)
summary(mxRun(factorModel))
```
An MxModel Contains Objects and Other MxModels

- `mxModel` contains objects and other MxModels.
- `mxMatrices` can have zero or more matrices.
- `mxAlgebras` can have zero or one type.
- `mxConstraints` can have independent type.
- `mxObjectivefunction` can have zero or one objective function.
- `mxData` can have zero or one data object.
- `Optimizer Options` can have zero or one optimizer options.
- `Output` can have zero or one output object.
An MxMatrix Contains Values and Metainformation

mxMatrix

- type
- ncols
- nrows
- name
- dimnames

Values
Labels
Free
Lower Bounds
Upper Bounds
Many MxMatrices Can Be in an MxModel
Labels Can Be Used For Equality Constraints

The OpenMx Team
University of Virginia
http://openmx.psyc.virginia.edu
Equality Constraints can be Between Submodels

<table>
<thead>
<tr>
<th>Model A</th>
<th>Submodel B</th>
<th>Submodel D</th>
</tr>
</thead>
<tbody>
<tr>
<td>mxMatrix</td>
<td>type</td>
<td>ncols</td>
</tr>
<tr>
<td>Values</td>
<td>Labels</td>
<td>Free</td>
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<td>Values</td>
<td>Labels</td>
<td>Free</td>
</tr>
</tbody>
</table>

Submodel B and Submodel D have equality constraints denoted by "c" in their dimensions and values.
Labels Can Constrain to Algebraic Results

mxModel A
mxMatrix
Values "c[1,1]"
Labels "c[2,2]"
Free
Lower Bounds
Upper Bounds
mxMatrix
Values "c[1,1]"
Labels "c[2,2]"
Free
Lower Bounds
Upper Bounds
mxAlgebra "c" = exp(Z) %*% W
Models Can Be Hierarchically Structured

![Diagram of models with sub-models showing Matrices, Algebra, Objective Function, Data, Constraints, and Options.](http://openmx.psyc.virginia.edu)
OpenMx is
- Free.
- Open Source (Apache 2.0 License).
- Available now as a public beta test from the OpenMx website.

OpenSEM is
- A community for SEM modelers, teachers, and students.
- A set of topic–based discussion forums.
- Open to users of any software, not just OpenMx.
- Free, with registration and login at the OpenMx website.

The OpenMx team hopes you find our work useful.