library(lavaan)

bootstrapN <- 500

# Data for DoubleModerationEMM

data <- matrix( c(0.9911 , 0.6104 , 0.7951 , 0.7787 ,

0.1222 , 0.5551 , -0.7836 , 0.348 ,

0.5084 , -0.6272 , 0.43 , 0.0622 ,

-0.7865 , -2.2149 , -1.604 , 0.4699 ,

0.3862 , -0.3306 , -1.5038 , -0.2649 ,

0.1688 , -0.1604 , -0.5885 , -0.161 ,

0.1338 , -0.0746 , 0.7511 , 0.9925 ,

-0.8198 , -2.0927 , -0.31 , -0.7791 ,

0.674 , 1.7168 , 0.7731 , 0.4104 ,

0.009 , -0.147 , 0.6538 , 0.6796 ,

-0.7148 , 0.6433 , -0.3829 , 0.4166 ,

0.5668 , 0.4832 , -0.5375 , -0.1321 ,

0.3982 , -0.0897 , -1.3657 , -0.4086 ,

0.5617 , 0.7184 , 0.6609 , 1.1078 ,

0.8674 , 0.7002 , -0.205 , 0.811 ,

-0.1981 , 0.2578 , 0.5142 , 0.0647 ,

0.4143 , -0.319 , 1.1025 , -0.2017 ,

-0.1392 , 0.1992 , 0.4837 , 0.501 ,

0.58 , 0.5575 , 0.4814 , 0.4469 ,

-0.5175 , -0.7564 , -0.4886 , -0.2165 ,

-0.2459 , -0.8419 , 2.3681 , -0.0158 ,

0.8508 , 0.7244 , 1.2367 , 1.4968 ,

0.8362 , 1.1822 , 1.5984 , 1.3212 ,

0.2929 , 0.4246 , 1.092 , 0.1135 ,

-0.6727 , 0.7858 , -0.7477 , -0.6106 ,

1.3491 , 0.7118 , 2.4409 , 1.4119 ,

0.6837 , 2.4265 , 0.2473 , 0.2678 ,

-0.7221 , 0.4005 , 0.4275 , -0.0591 ,

-0.2085 , -1.3268 , -0.5577 , 0.0804 ,

0.5415 , -0.4619 , -0.0672 , -0.8737 ,

-0.6264 , -1.7149 , -0.8137 , -1.2623 ,

0.9637 , 1.0565 , -0.5735 , 0.4472 ,

0.0278 , -0.009 , 0.3138 , 0.2091 ,

-0.0402 , -1.5819 , -1.4 , -0.2898 ,

-0.8429 , -0.7487 , 0.5774 , -0.4491 ,

0.0951 , -0.8451 , 0.8043 , -1.0437 ,

-0.529 , -1.955 , -0.8823 , -0.3577 ,

-0.1652 , 0.1175 , -1.232 , -0.9222 ,

0.206 , -0.6373 , -0.8596 , -0.627 ,

0.2425 , -0.7727 , 0.5039 , -0.3855 ,

2.0811 , 1.2235 , 0.7957 , 1.3801 ,

-0.3414 , 0.5219 , -1.3132 , -0.6635 ,

-0.0897 , -0.069 , -1.6032 , -0.0978 ,

-0.9725 , -0.5657 , -1.6381 , -0.6444 ,

0.506 , 1.5862 , -1.0117 , -0.5778 ,

-0.299 , -0.3961 , -0.007 , 0.435 ,

1.5398 , 1.7552 , 0.9293 , 0.9815 ,

-0.6195 , -0.2354 , 0.5929 , 0.6267 ,

-0.8491 , -0.4842 , 0.5009 , -0.6614 ,

0.034 , 0.0995 , -0.5985 , 0.2548 ), 50 , 4 , byrow=TRUE)

data <- as.data.frame(data)

colnames(data) <- c("Y", "X", "Z", "M")

# Lavaan Model for DoubleModerationEMM

lavaan.model <- '

# Models Analyzed

M ~ aZ \* Z + aX \* X + aXZ \* X:Z

Y ~ bM \* M + bX \* X + bXM \* X:M

# Mean of (Centered) Moderator

X ~ X.mean \* 1

# Variance of (Centered) Moderator

X ~~ X.var \* X

# Effects on Mediator conditional on moderator

ZtoM.SDlo := (aZ + aXZ \* (X.mean - sqrt(X.var)))

ZtoM.SDhi := (aZ + aXZ \* (X.mean + sqrt(X.var)))

# Indirect Effects Conditional on Moderator

indirect.SDlo := (bM + bXM \* (X.mean - sqrt(X.var))) \* ZtoM.SDlo

indirect.SDhi := (bM + bXM \* (X.mean + sqrt(X.var))) \* ZtoM.SDhi

# Index of Moderated Mediation (alternativ test for sign. differences among different moderator levels)

index.mod.med: = ( aZ + aXZ ) \* bXM

# Covariance of Exogeneous Variables

X ~~ Z'

# Fit model to data

set.seed(300566)

lavaan.model.fit <- sem(model = lavaan.model,

data = data,

se = "bootstrap",

bootstrap = bootstrapN)

# Bootstrap confidence intervals

CI\_BS <- parameterEstimates(lavaan.model.fit,

boot.ci.type = "bca.simple",

level = .95, ci = TRUE,

standardized = FALSE)

# Display Results

CI\_BS

# Display Results EXAMPLE

# "lhs" "op" "rhs" "label" "est" "se" "z" "pvalue" "ci.lower" "ci.upper"

# "M" "~" "Z" "aZ" "0.3" "0.062" "4.845" "0" "0.191" "0.459"

# "M" "~" "X" "aX" "0.3" "0.082" "3.676" "0" "0.148" "0.468"

# "M" "~" "X:Z" "aXZ" "0.3" "0.079" "3.797" "0" "0.13" "0.459"

# "Y" "~" "M" "bM" "0.3" "0.11" "2.728" "0.006" "0.075" "0.506"

# "Y" "~" "X" "bX" "0.3" "0.068" "4.399" "0" "0.177" "0.469"

# "Y" "~" "X:M" "bXM" "0.3" "0.129" "2.333" "0.02" "0.125" "0.621"

# "X" "~1" "" "X.mean" "0" "0.142" "0" "1" "-0.302" "0.272"

# "X" "~~" "X" "X.var" "0.98" "0.193" "5.08" "0" "0.651" "1.436"

# "Z" "~~" "X" "" "0.294" "0.133" "2.207" "0.027" "0.022" "0.539"

# "M" "~~" "M" "" "0.196" "0.029" "6.841" "0" "0.153" "0.265"

# "Y" "~~" "Y" "" "0.196" "0.03" "6.43" "0" "0.152" "0.284"

# "Z" "~~" "Z" "" "0.98" "0.174" "5.647" "0" "0.707" "1.469"

# "X:Z" "~~" "X:Z" "" "0.876" "0" NA NA "0.876" "0.876"

# "X:Z" "~~" "X:M" "" "0.222" "0" NA NA "0.222" "0.222"

# "X:M" "~~" "X:M" "" "0.392" "0" NA NA "0.392" "0.392"

# "M" "~1" "" "" "0" "0.067" "0" "1" "-0.127" "0.133"

# "Y" "~1" "" "" "0" "0.073" "0" "1" "-0.161" "0.129"

# "Z" "~1" "" "" "0" "0.142" "0" "1" "-0.289" "0.265"

# "X:Z" "~1" "" "" "0.294" "0" NA NA "0.294" "0.294"

# "X:M" "~1" "" "" "0.327" "0" NA NA "0.327" "0.327"

# "ZtoM.SDlo" ":=" "(aZ+aXZ\*(X.mean-sqrt(X.var)))" "ZtoM.SDlo" "0.003" "0.13" "0.023" "0.981" "-0.256" "0.244"

# "ZtoM.SDhi" ":=" "(aZ+aXZ\*(X.mean+sqrt(X.var)))" "ZtoM.SDhi" "0.597" "0.093" "6.391" "0" "0.409" "0.789"

# "indirect.SDlo" ":=" "(bM+bXM\*(X.mean-sqrt(X.var)))\*ZtoM.SDlo" "indirect.SDlo" "0" "0.019" "0" "1" "-0.058" "0.032"

# "indirect.SDhi" ":=" "(bM+bXM\*(X.mean+sqrt(X.var)))\*ZtoM.SDhi" "indirect.SDhi" "0.356" "0.126" "2.82" "0.005" "0.137" "0.64"

# "index.mod.med" ":=" "(aZ+aXZ)\*bXM" "index.mod.med" "0.18" "0.087" "2.065" "0.039" "0.071" "0.428"

# NOTES

# 1) ZtoM.SDlo & ZtoM.SDhi are the direct effects from Z to M conditional on the moderator.

# 2) indirect.SDlo & indirect.SDhi are the indirect effects from Z to Y via M conditional on the moderator.

# 3) direct.SDlo & direct.SDhi are the direct effects from Z to Y conditional on the moderator (only shown of direct effects are included)

# 4) total.SDlo & total.SDhi are the total effects from Z to Y conditional on the moderator (only shown of direct effects are included).

# 5) prop.medtd.SDl & prop.medtd.SDh are the proportion of effects from Z to Y conditional on the moderator (only shown of direct effects are included).

# 6) index.mod.med is an alternative way of testing if conditional indirect effects are significantly different.

# Setup of lavaan models was inspired by Anthony N. Washburn (https://ademos.people.uic.edu/Chapter15.html#5\_moderated\_mediation\_analyses\_using\_"lavaan"\_package)