

Interactive, Dynamic, and Automated SEMs for Maximal Productivity

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“There is no delight in owning anything unshared”

Lucius Annaeus Seneca the Younger, Roman Stoic Philosopher



Outline

SEM in JMP Pro

- Preliminary info
- Design of SEM platform
- Demo
 - Confirmatory Factor Analysis
 - Path Analysis with Latent Variables
 - Longitudinal Analysis
- Resources and Q&A

Highlight prez/pub prep

Preliminaries

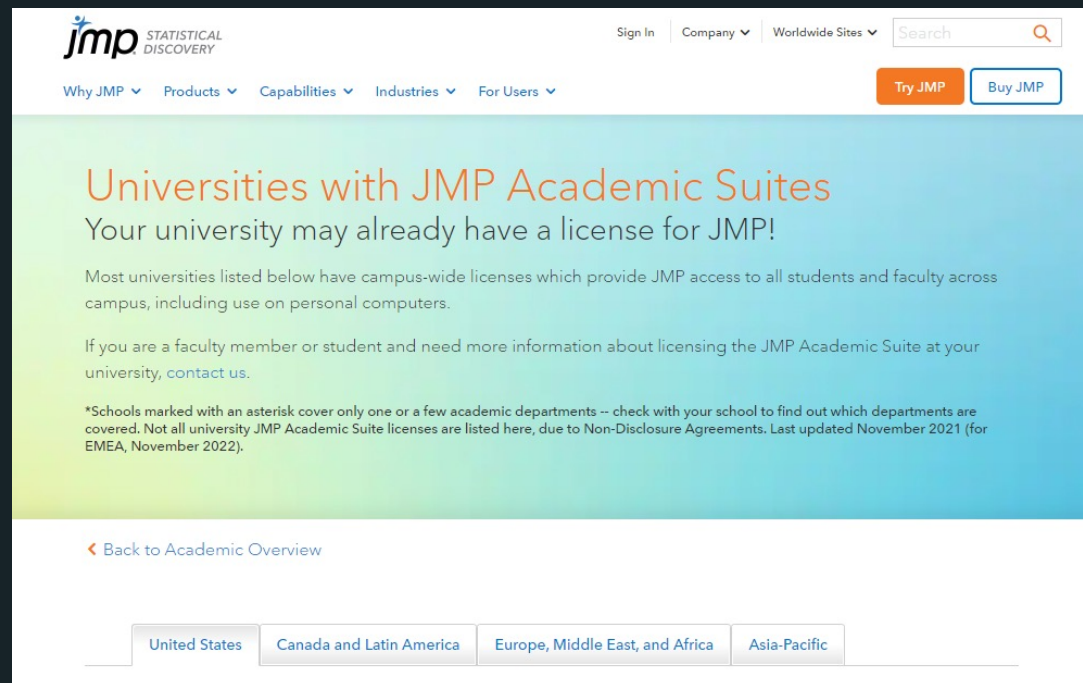
Lead Developer of SEM in JMP Pro

I'm in R&D --- very, *very* removed from sales

Preliminaries

[Very likely] You already have JMP Pro

https://www.jmp.com/en_us/academic/university-list.html



The screenshot shows the top portion of the JMP website's 'University List' page. The header includes the JMP logo, navigation links for 'Sign In', 'Company', and 'Worldwide Sites', a search bar, and buttons for 'Try JMP' and 'Buy JMP'. Below the header, the main heading reads 'Universities with JMP Academic Suites' followed by the sub-heading 'Your university may already have a license for JMP!'. The text explains that most listed universities have campus-wide licenses and provides contact information for faculty or students. A disclaimer at the bottom of the text block states that schools marked with an asterisk have limited departmental coverage. At the bottom of the page, there is a 'Back to Academic Overview' link and a set of tabs for regional filtering: 'United States', 'Canada and Latin America', 'Europe, Middle East, and Africa', and 'Asia-Pacific'.

jmp STATISTICAL DISCOVERY

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Most universities listed below have campus-wide licenses which provide JMP access to all students and faculty across campus, including use on personal computers.

If you are a faculty member or student and need more information about licensing the JMP Academic Suite at your university, contact us.

*Schools marked with an asterisk cover only one or a few academic departments – check with your school to find out which departments are covered. Not all university JMP Academic Suite licenses are listed here, due to Non-Disclosure Agreements. Last updated November 2021 (for EMEA, November 2022).

[Back to Academic Overview](#)

United States Canada and Latin America Europe, Middle East, and Africa Asia-Pacific

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jmp STATISTICAL DISCOVERY

Preliminaries

What and who is JMP?

- SAS != JMP (two versions: JMP and JMP Pro –SEM is in the latter)
- Stats software for scientists and engineers (since 1989)
- Outstanding SEM team

- Christopher Gotwalt, Ph.D., Chief Data Science Officer

Really difficult stuff

- James Koepfler, Ph.D., Senior Research Stat Tester

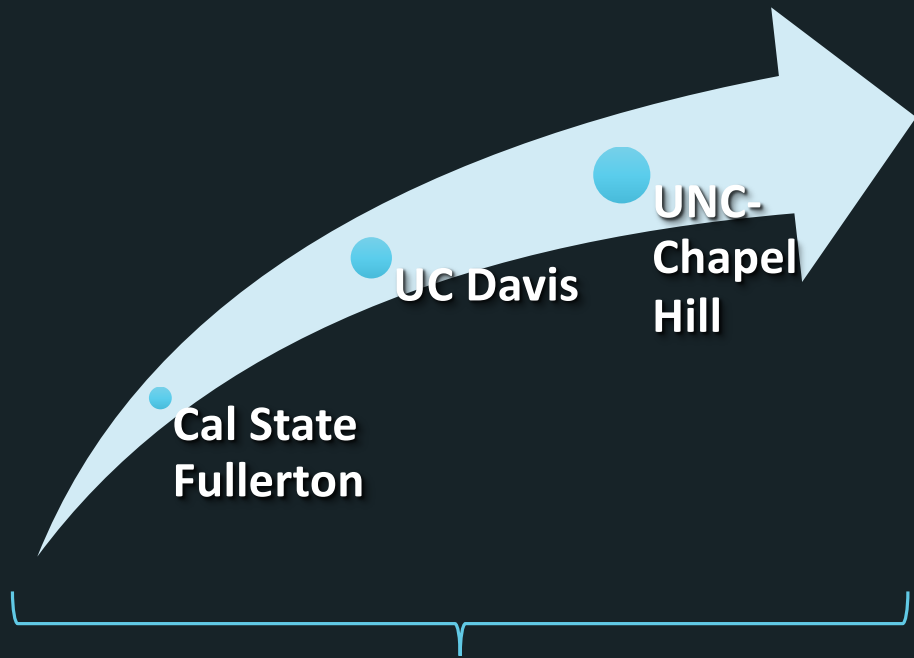
Testing

- Eric Russo, Research Developer

Path diagram algorithms

- and others

Design of SEM Platform



10 Years Applied SEM Experience

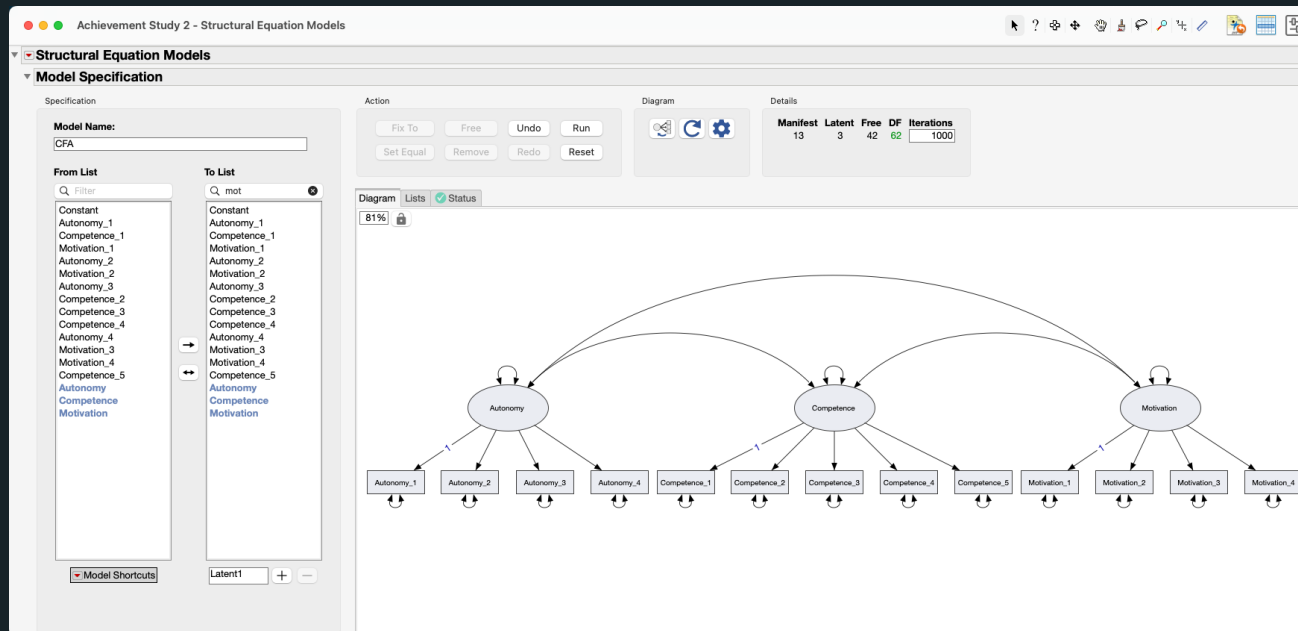
SAS/JMP

Opportunity to revamp SEM software based on first-hand experience

Design of SEM Platform

What are the pain points of fitting SEMs?

- Creating path diagrams is a separate, time-consuming endeavor
- PowerPoint deck with common path diagrams are often passed down

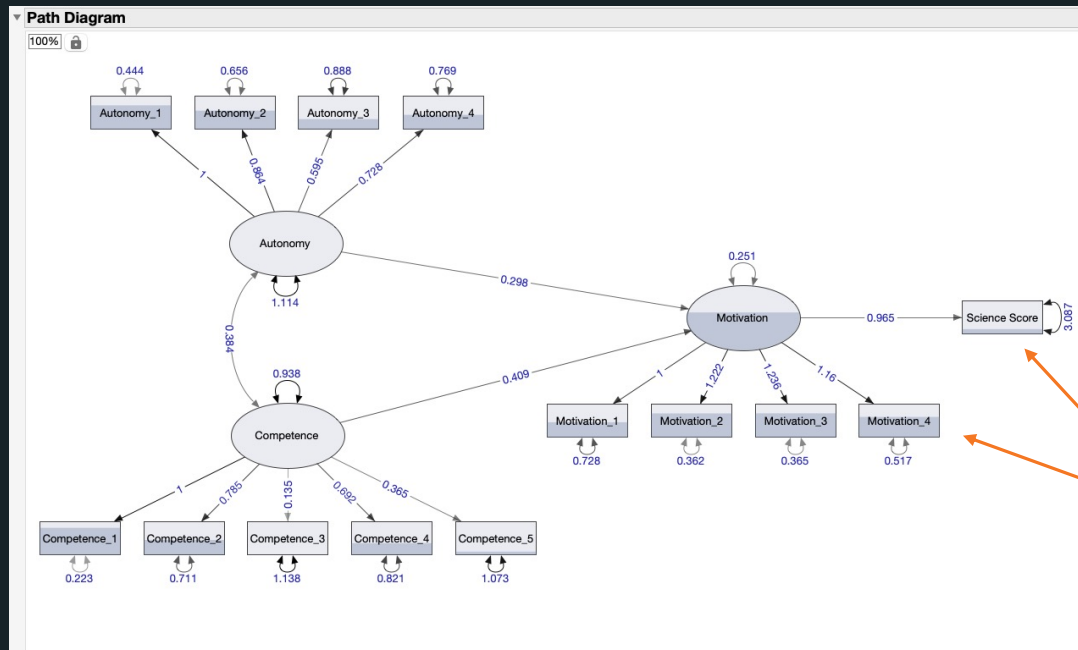


- High-quality, prez-ready, fully customizable path diagrams are created for you

Design of SEM Platform

What are the pain points of fitting SEMs?

- Creating path diagrams is a separate, time-consuming endeavor
- PowerPoint deck with common path diagrams are often passed down



Can be pasted as vectorized image

Shading = proportion of variance explained

- High-quality, prez ready, fully customizable path diagrams are created for you

Design of SEM Platform

What are the pain points of fitting SEMs?

- Compelled to come up with shortcuts (code, algorithms, 'tricks') for time-consuming tasks
 - Specifying models
 - Comparing models with likelihood ratio or chi-square diff tests
 - Creating tables for reports
 - Collapsing information across many fitted models

Design of SEM Platform

What are the pain points of fitting SEMs?

- Compelled to come up with shortcuts (code, algorithms, ‘tricks’) for time-consuming tasks

The screenshot displays the 'Political Democracy - Structural Equation Models' window in JMP. It features a table for model comparison and a Chi-Square Difference Test section.

Model Name	-2 Log Likelihood	Number of Parameters	AICc	AICc Weight	.2	.4	.6	.8	BICu	ChiSquare	DF	Prob>ChiSq	CFI	RMSEA	Lower 90%	Upper 90%
1 Unrestricted (Saturated)	3057.4567	77	.	.					0.0000	0.0000	0	.	1.0000	0.0000	0.0000	0.0000
2 Independence	3788.1108	22	3851.5723	0.0000					493.1922	730.6541	55	<.0001*	0.0000	0.4047	0.3789	0.4311
3 Industrialization and Political Democracy	3097.6362	39	3264.779	0.9632					-123.8851	40.1795	38	0.3739	0.9968	0.0277	0.0000	0.0871
4 Release equality constraints on loadings	3095.5819	42	3292.4569	0.0000					-112.9869	38.1252	35	0.3292	0.9954	0.0345	0.0000	0.0922
5 Remove across-time unique factor covariances	3115.3707	38	3273.7041	0.0111					-110.4680	57.9141	39	0.0261*	0.9720	0.0804	0.0287	0.1218
6 Remove within-time unique factor covariances	3129.9183	36	3272.0235	0.0257					-104.5554	72.4616	41	0.0018*	0.9534	0.1012	0.0614	0.1387

[Compare Selected Models](#) [Clear Selection](#)

Chi-Square Difference Test

Model nested...	...in model	ΔChiSquare	ΔDF	Prob>ChiSq	ΔCFI	ΔRMSEA
Industrialization and Political Democracy	Release equality constraints on loadings	2.0543	3	0.5612	0.0014	-0.007
Remove across-time unique factor covariances	Release equality constraints on loadings	19.7888	4	0.0005*	-0.023	0.0459
Remove within-time unique factor covariances	Remove across-time unique factor covariances	14.5475	2	0.0007*	-0.019	0.0207

Difference tests are meaningful only for nested models

- ▶ Structural Equation Model: Industrialization and Political Democracy
- ▶ Structural Equation Model: Release equality constraints on loadings
- ▶ Structural Equation Model: Remove across-time unique factor covariances
- ▶ Structural Equation Model: Remove within-time unique factor covariances

All those tasks are done for you, saving lots of time

Interactive model comparison

Tables ready to copy/paste with relevant info (or customize)

Design of SEM Platform

What are the pain points of fitting SEMs?

- Reverse-engineer issues that arise upon fitting a model
- Dictionary of common warnings and their possible meaning
 - Non-positive definite
 - Model might not be identified
 - And many more...

Design of SEM Platform

What are the pain points of fitting SEMs?

- Reverse-engineer issues that arise upon fitting a model

Diagram Lists **Status**

Identification Rules

Name	Pass	Necessary	Sufficient
t-Rule	✓	Yes	No
Sample Size Rule	✓	Yes	No
Two-Indicator Rule	-	No	No
Three-Indicator Rule	✓	No	No
Latent Scale Set	✓	Yes	No
Two Emitted Path Rule	✓	Yes	No
Recursive Rule	✓	No	No

Checks if there are more knowns than equations in the model. This test must pass to identify the model.

*All rules assume a positive definite covariance matrix

Model Details

Manifest Variables	11
Latent Variables	3
Freely Estimated Parameters	36
Covariance Structure DF	41
Mean Structure DF	0
Total DF	41
Equality Constraints	0
Fixed Parameters	3
Exogenous Variables	1
Endogenous Variables	13

Data Details

Total Sample Size	75
Rows with Complete Data	75
Rows with Some Missing Data	0
Rows with All Missing Data	0

Identification rules are examined with every change to the model specification

Interactive UI provides description of rules

Useful model/data details

Diagram Lists **Status**

Identification Rules

Name	Pass	Necessary	Sufficient
t-Rule	✓	Yes	No
Sample Size Rule	✓	Yes	No
Two-Indicator Rule	✗	No	No
Three-Indicator Rule	✗	No	No
Latent Scale Set	✗	Yes	No
Two Emitted Path Rule	✓	Yes	No
Recursive Rule	✗	No	No

Checks if the model has feedback loops (is nonrecursive). Instrumental variables are needed to identify the model if this test fails.

*All rules assume a positive definite covariance matrix

Model Details

Manifest Variables	11
Latent Variables	3
Freely Estimated Parameters	37
Covariance Structure DF	40
Mean Structure DF	0
Total DF	40
Equality Constraints	0
Fixed Parameters	2
Exogenous Variables	2
Endogenous Variables	12

Data Details

Total Sample Size	75
Rows with Complete Data	75
Rows with Some Missing Data	0
Rows with All Missing Data	0

Not all exogenous variables covary with each other. This might be purposeful or a specification error.

- Status tab provides dynamic feedback at every step of model specification

Design of SEM Platform

What are the pain points of fitting SEMs?

~~Pain Points~~

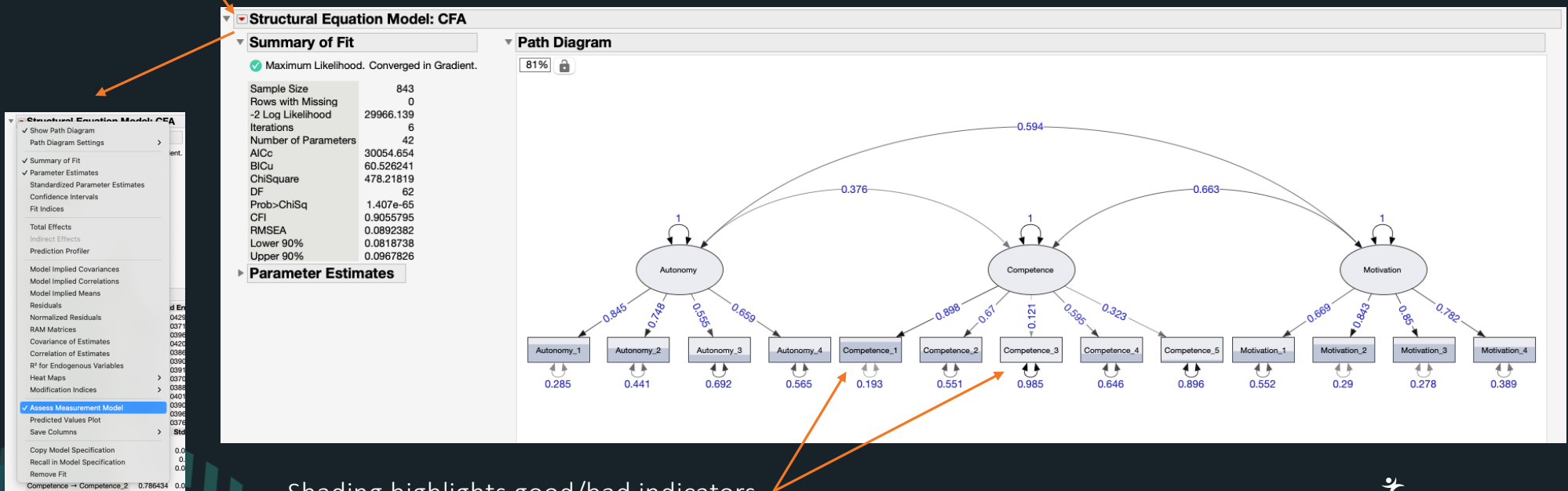
DEMO

- Measuring factors that influence achievement
- Testing a theory of motivation and achievement
- Characterizing achievement trajectories over time

Confirmatory Factor Analysis

Measuring factors that influence achievement

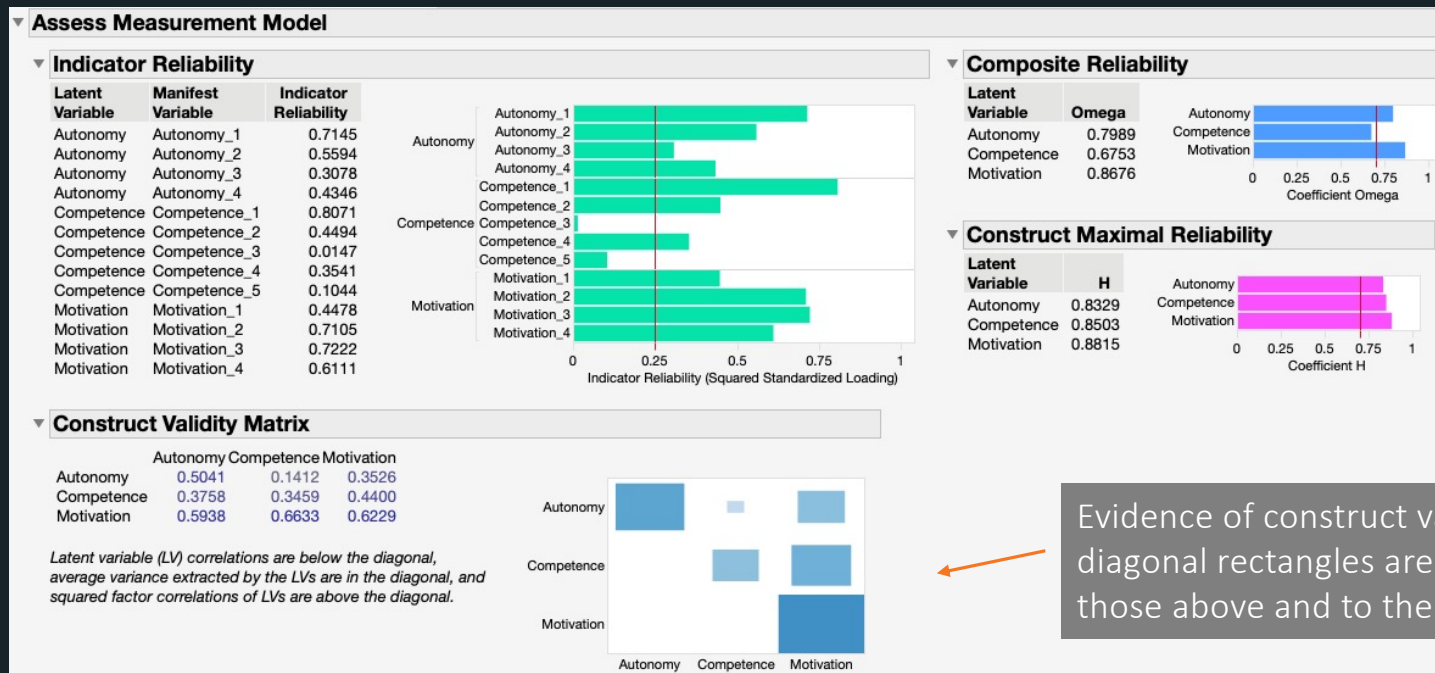
Red triangles display menus with all model output options



Shading highlights good/bad indicators

Assess Measurement Model

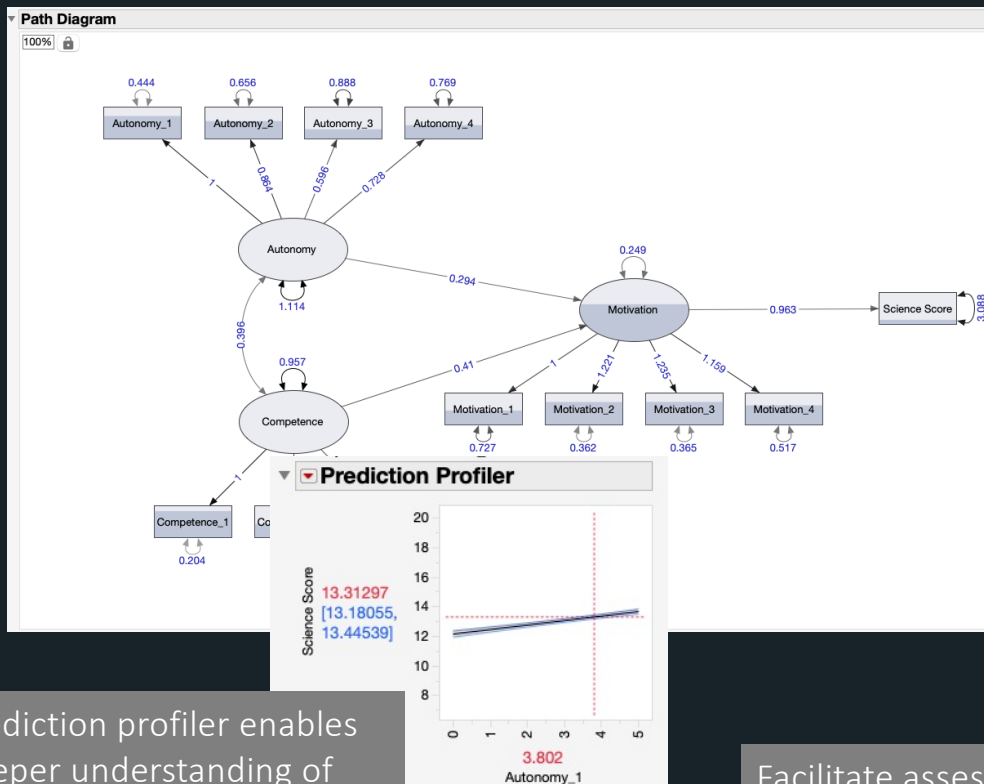
One-Stop Shop for Reliability and Validity



Path Analysis with Latent Variables

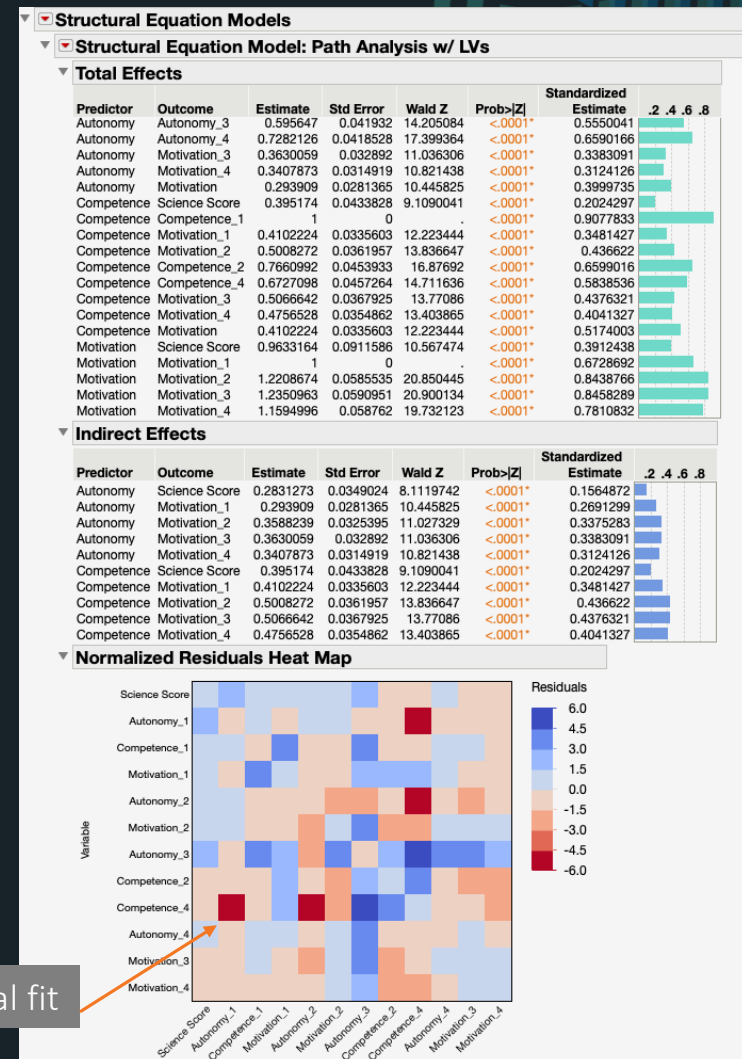
Testing a Theory of Motivation and Achievement

Visualizations through out to facilitate interpretation of results



Prediction profiler enables deeper understanding of model implications

Facilitate assessment of local fit



Longitudinal Analysis

Characterizing Trajectories Over Time

The screenshot displays the 'Structural Equation Models' window in JMP. The 'Model Specification' section is active, showing a 'Linear Growth Model' with the following parameters:

Manifest	Latent	Free	DF	Iterations
4	2	9	5	1000

The diagram shows a latent variable '1' (Intercept) and another latent variable 'Slope'. Both latent variables have self-loops. The Intercept latent variable is connected to four manifest variables: 'Multipl... Year1', 'Multipl... Year2', 'Multipl... Year3', and 'Multipl... Year4'. The Slope latent variable is also connected to these four manifest variables. The manifest variables have self-loops. A 'Define Time Values' menu is open, listing various growth curve models, with 'Longitudinal Analysis' selected.

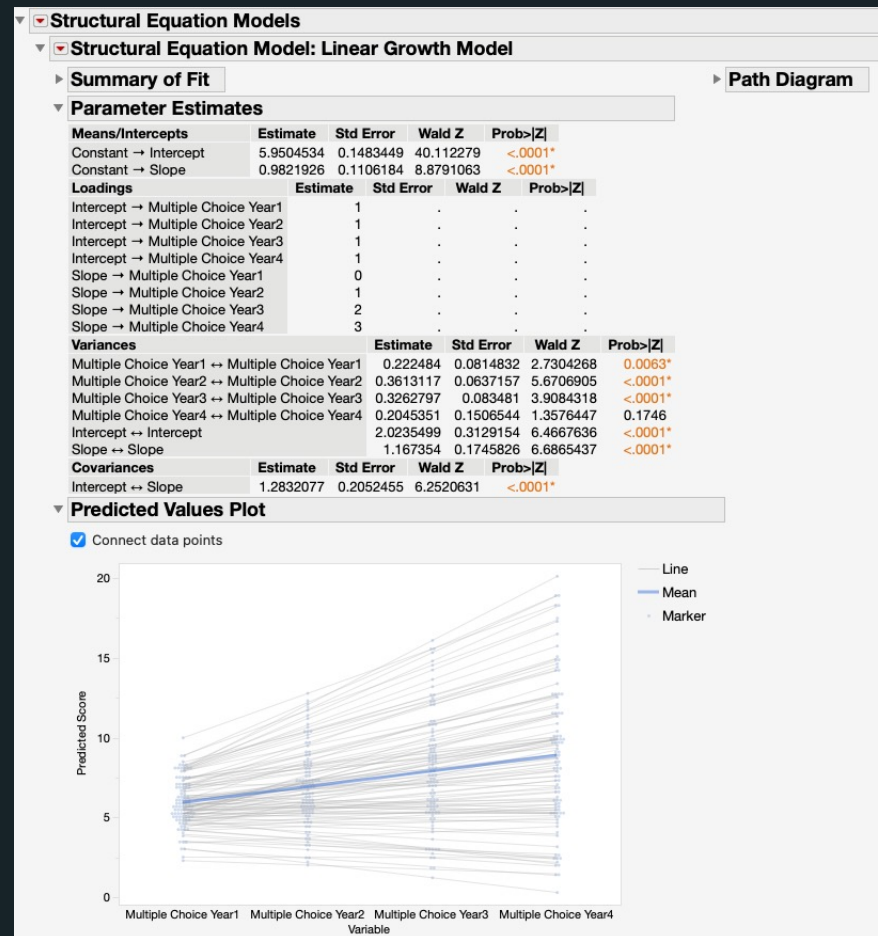
Model Shortcuts menu enables simple specification of common models

Predicted Values Plot

Model-Implied Trajectories

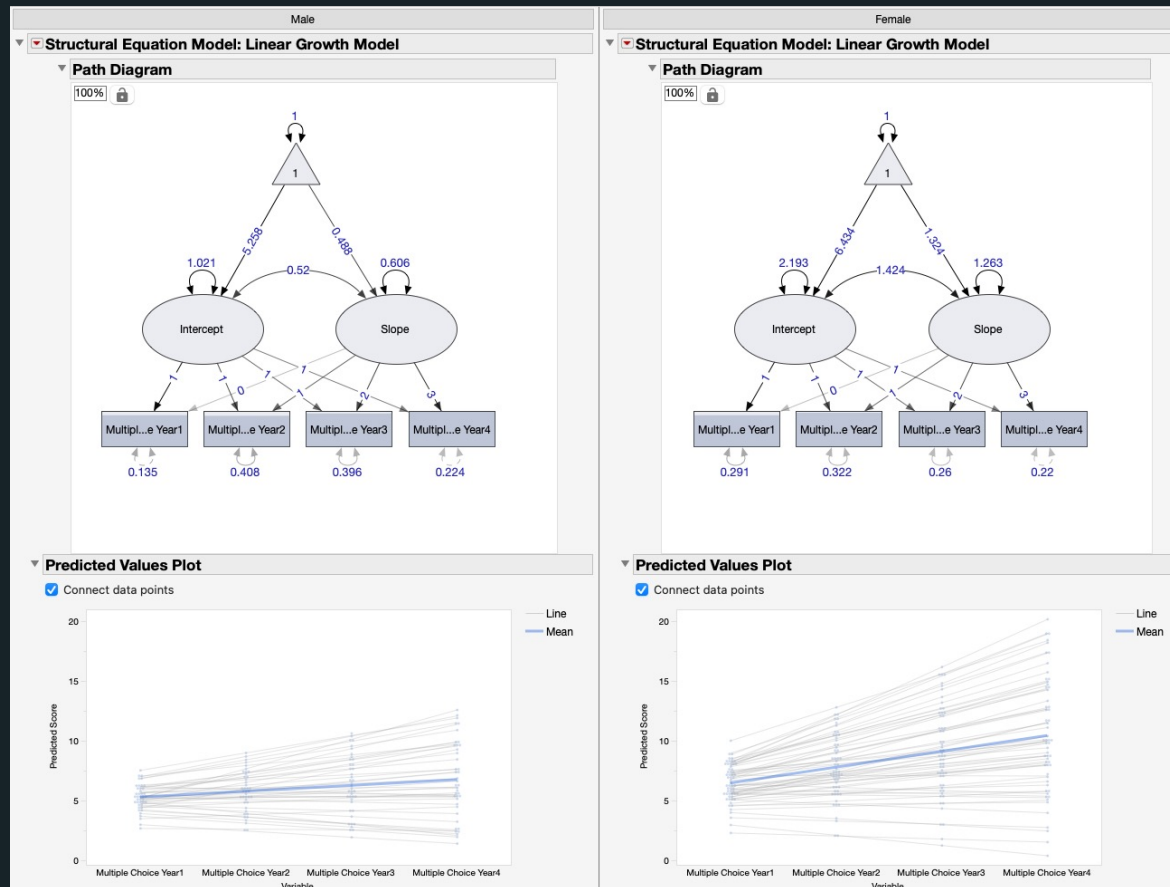
Paths in table of parameter estimates are interactively linked to paths in path diagram

Visualizations are interactive and linked to data and other visualizations



Multiple-Group Analysis

Optional Side-by-Side Display of Results



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FAQs

STRUCTURAL EQUATION MODELING: A MULTIDISCIPLINARY JOURNAL
<https://doi.org/10.1080/10705511.2020.1854764>

 **Routledge**
Taylor & Francis Group

 Check for updates

Fitting Structural Equations Models with Interactive and Dynamic Tools in JMP® Pro

Laura Castro-Schilo and Eric Russo

SAS Institute Inc.

ABSTRACT

We offer a tutorial for using a new, interactive, and dynamic Structural Equation Modeling (SEM) platform in JMP Pro v16.0 to fit three commonly used models: (1) Confirmatory Factor Analysis, (2) Path Analysis with Latent Variables, and (3) Longitudinal Factorial Invariance Analysis. We highlight features of JMP Pro through these examples including, an end-to-end workflow that enables all stages of data manipulation, visualization, analysis, and presentation, the dynamic feedback provided in the SEM specification process to guard against errors, interactive customizations of path diagrams and model comparison tools, novel visualizations for assessing reliability and validity of measurement models, and sharing capabilities for enabling collaborations.

KEYWORDS

Structural equation modeling; JMP®; confirmatory factor analysis; path analysis; longitudinal factorial invariance

Castro-Schilo, L., & Russo, E. (2021). Fitting Structural Equations Models with Interactive and Dynamic Tools in JMP® Pro. *Structural Equation Modeling: A Multidisciplinary Journal*, 28, 794-806.

*A bit outdated, we have many more features now

Example one: Confirmatory factor analysis and evaluating measurement models

Kachanoff et al. (2020) set out to investigate a construct that had not been measured before; namely, the perceptions of realistic and symbolic COVID-19 threats. They defined realistic threat as per-

Example two: Building path models with latent variables

A key question tackled by Kachanoff et al. (2020), was whether perceptions of COVID-19 threats were linked to public health behaviors (PHB) recommended by the centers for disease

Application three: Longitudinal factorial invariance

In the previous examples, we showed that a “Constant” is always included in the From and To lists of the UI (see lists in Figure 3). Indeed, the reason is that the mean structure is

FAQs

DOI: 10.1111/cdev.13908

EMPIRICAL ARTICLE

CHILD DEVELOPMENT

Longitudinal links between maternal cultural socialization, peer ethnic-racial discrimination, and ethnic-racial pride in Mexican American youth

Gabriela Livas Stein¹ | N. Keita Christophe² | Laura Castro-Schilo³ |
 Casandra Gomez Alvarado¹ | Richard Robins⁴

Stein, G. L., Christophe, N. K., Castro-Schilo, L., Gomez Alvarado, C., & Robins, R. (2023). Longitudinal links between maternal cultural socialization, peer ethnic-racial discrimination, and ethnic-racial pride in Mexican American youth. *Child Development, 94*, 752-767.

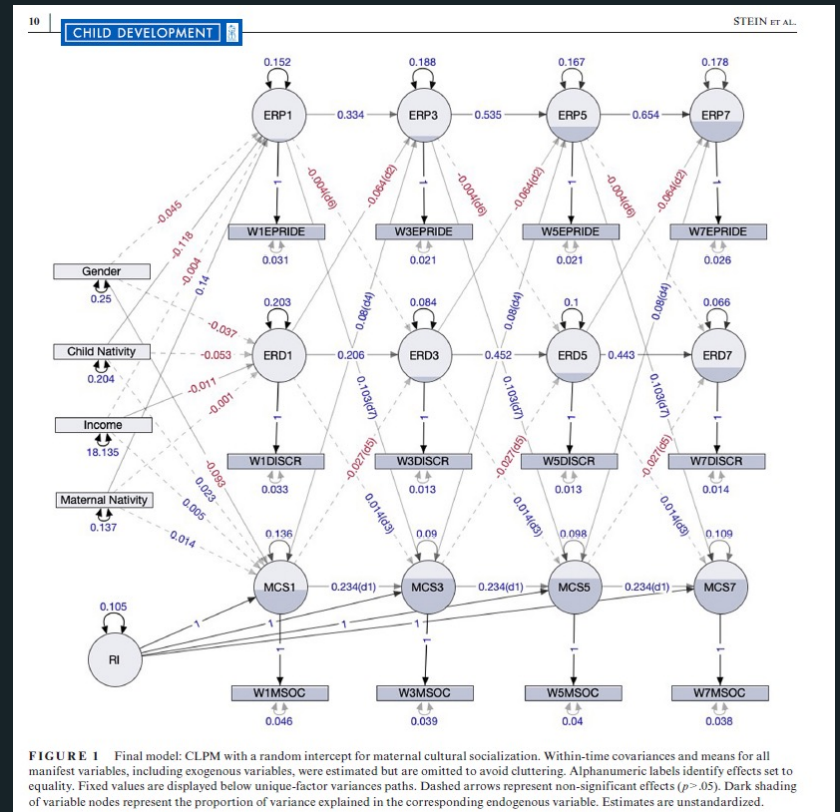


FIGURE 1 Final model: CLPM with a random intercept for maternal cultural socialization. Within-time covariances and means for all manifest variables, including exogenous variables, were estimated but are omitted to avoid cluttering. Alphanumeric labels identify effects set to equality. Fixed values are displayed below unique-factor variances paths. Dashed arrows represent non-significant effects ($p > .05$). Dark shading of variable nodes represent the proportion of variance explained in the corresponding endogenous variable. Estimates are unstandardized.

FAQs

- SEM in JMP Pro is new
- Lots of work ahead to add more features
- But...

what we do, we do very well

“There is no delight in owning anything unshared”

Lucius Annaeus Seneca the Younger, Roman Stoic Philosopher

Resources

There are a LOT

2-5 min videos on a variety of topics to get started:

https://www.jmp.com/en_us/jmp-trial/learn-the-basics-of-jmp.html

Academic Team (course prep & faculty support):

https://www.jmp.com/en_us/academic.html

Director: Curt.Hinrichs@jmp.com

Online documentation:

<https://www.jmp.com/support/help/en/17.1/>



Thank you!

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