



دانشگاه علوم پزشکی و خدمات بهداشتی درمانی کرمانشاه
 معاونت تحقیقات و فناوری

کارگاه مقدماتی مدل یابی معادلات ساختاری (Structural Equation Model)

با همکاری گروه اپیدمیولوژی و گروه آمار زیستی
 دانشگاه علوم پزشکی کرمانشاه

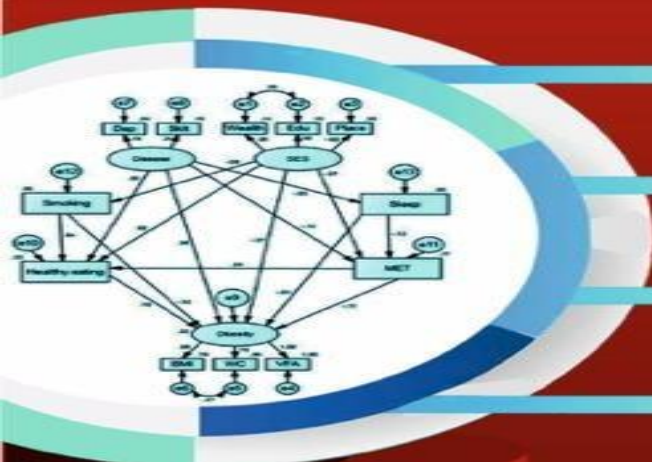
ارائه دهندگان :

دکتر فرید نجفی

دکتر مهدی مرادی نظر

دکتر شایان مصطفایی

میترا دربندی



دوشنبه ۹۹/۶/۳



۱۲:۳۰ تا ۸:۳۰



علاقتمندان در سراسر کشور می توانند از طریق
 آدرس اینترنتی زیر در کارگاه شرکت نمایند .

VC.Kums.ac.ir/kumsresearch

شرکت کنندگان برای اتصال نیاز به نرم افزار

Adobe connect دارند

Factor Analysis

Mehdi Moradinazar

*Dept. of Epidemiology, Kermanshah University of
Medical Sciences, Iran*

m.moradinazar@gmail.com
m.moradinazar@kums.ac.ir



دانشگاه علوم پزشکی و خدمات بهداشتی درمانی کرمانشاه

Topics

- ❖ What is Factor Analysis(FA)?
- ❖ Exploratory vs. Confirmatory Factor Analysis
- ❖ EFA CFA Implementation Steps
- ❖ Path analysis



Factor analysis

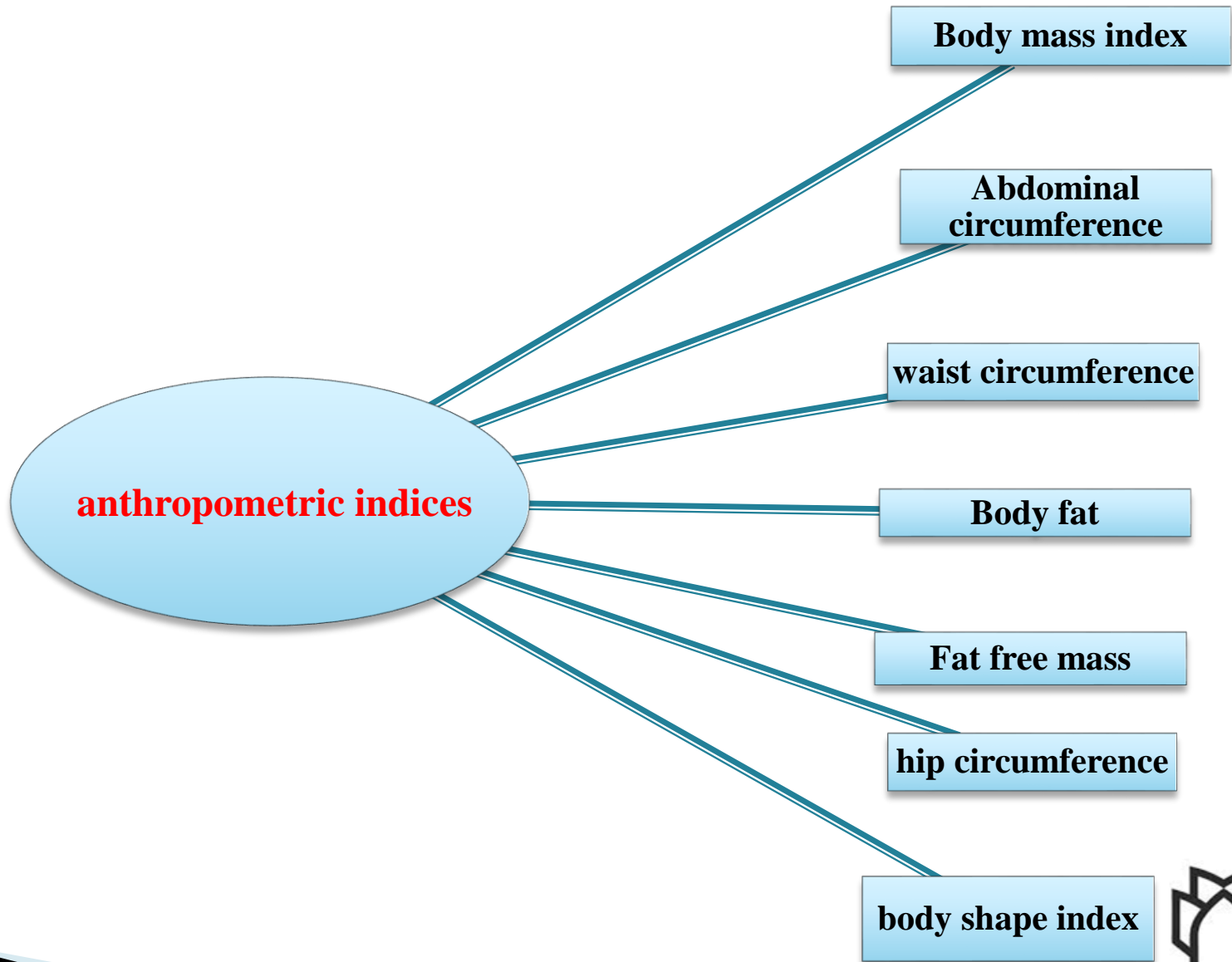
- ❖ Factor analysis is a statistical test that is used to find relationships between multiple correlated measures and *Charles Edward Spearman* played a clear part in its development.
- ❖ Factor analysis is a technique that is used to reduce a large number of variables into fewer numbers of factors.
- ❖ It is one of the multivariate methods in which all variables are inter dependent and the concept of modeling based on independent and dependent variables does not apply.
- ❖ Simplify factor analysis of complex data by describing it in terms of fewer variables, based on variance between several dependent variables



The main applications of factor analytic techniques are:

- ❑ To *reduce* the number of variables
- ❑ To *detect structure* in the relationships between variables





پرسشنامه‌ی جدایی روان‌شناختی

کاملاً صادق است	تا حد زیاد صادق است	تا حدی درست است	خیلی کم صادق است	هرگز درست نیست	عبارت	
					بعضی وقت‌ها احساس می‌کنم که مادرم وبال گردنم است.	۱
					هنگامی که از مادرم به مدت‌زمان زیادی دور می‌مانم، احساس شادمانی می‌کنم.	۲
					نظر من در مورد صفات ارثی شبیه پدرم است.	۳
					در انتخاب دوستانم خواسته‌های مادرم مؤثر بوده است.	۴
					احساس می‌کنم که دائماً با مادرم می‌جنگم.	۵
					بسیاری از مشکلاتی که دارم، مادرم را مقصر می‌دانم.	۶
					کاش بیشتر می‌توانستم به مادرم اعتماد کنم.	۷
					نگرش من در مورد قباحث و زشتی شبیه نگرش مادرم است.	۸
					وقتی که مشکلی پیدا می‌کنم، معمولاً برای حل آن به مادرم متوسل می‌شوم.	۹
					برایم بااهمیت‌ترین شخص در دنیا، مادرم است.	۱۰
					من باید مراقب باشم تا به احساسات مادرم صدمه نزنم.	۱۱
					عقیده‌ام در مورد نقش زن شبیه نظر مادرم است.	۱۲
					اغلب از مادرم می‌خواهم تا در حل مشکلات شخصی‌ام به من کمک کند.	۱۳
					گاهی اوقات احساس می‌کنم که توسط مادرم تنبیه می‌شوم.	۱۴
					کاشکی مادرم بیش‌ازاندازه حمایت‌کننده نبود.	۱۵
					عقاید من در مورد نقش مرد شبیه نظر مادرم است.	۱۶
					من بدون تأیید مادرم نمی‌توانم یک خرید عمده را انجام دهم.	۱۷
					کاش مادرم زیاد مرا تحت نفوذ خود قرار نمی‌داد.	۱۸
					ای کاش مادرم مرا بازپچه دست خود قرار نمی‌داد.	۱۹
					عقاید مذهبی من شبیه مادرم است.	۲۰



Exploratory vs. Confirmatory Factor Analysis

□ Exploratory:

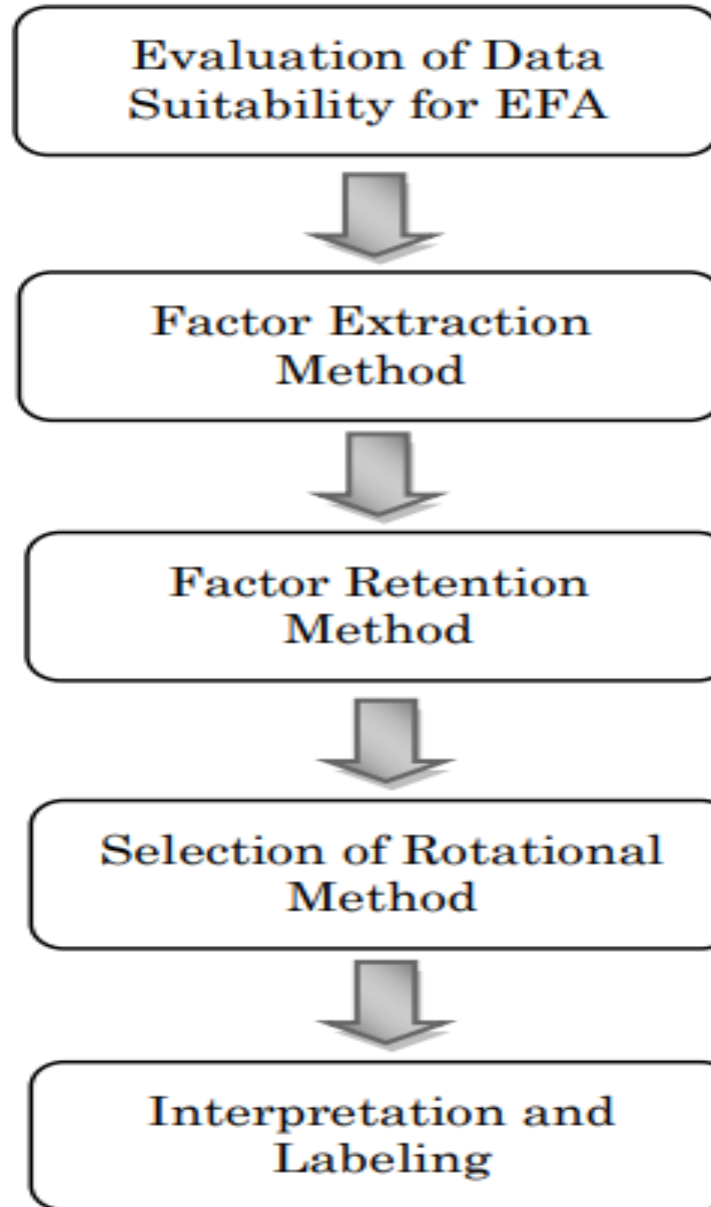
- **summarize** data
- **describe** correlation structure between variables
- **generate hypotheses**

□ Confirmatory

- ❖ CFA starts with a **hypothesis** about **how many factors** there are and **which items load on which factors**



Exploratory Factor Analysis Implementation Steps



1. *Evaluation of Data Suitability for EFA*

❖ *Kaiser-Meyer-Olkin (KMO)*

- ❑ measure of sampling adequacy
- ❑ KMO returns values between 0 and 1. (0 worse, 1 better)

❖ *Bartlett's test of sphericity*

- ❑ variables are related (correlation) and therefore suitable for structure detection.
- ❑ Small values (less than 0.05) of the significance level indicate that a factor analysis may be useful with your data.
- ❑ Normality (*interval or ratio levels*), Linearity, Outliers



2. *Factor Extraction*

- ❖ Maximum likelihood
- ❖ Principal components analysis (PCA)
- ❖ Principal axis factoring (PAF)
- ❖ Image factoring
- ❖ Alpha factoring
- ❖ Unweighted least squares
- ❖ Generalised least squares



Extraction method

- ▶ *Principal Components Analysis.*
- ▶ A factor extraction method used to form uncorrelated linear combinations of the observed variables. The first component has maximum variance. Successive components explain progressively smaller portions of the variance and are all uncorrelated with each other. Principal components analysis is used to obtain the initial factor solution. It can be used when a correlation matrix is singular.
- ▶ *Principal Axis Factoring.*
- ▶ A method of extracting factors from the original correlation matrix, with squared multiple correlation coefficients placed in the diagonal as initial estimates of the communalities. These factor loadings are used to estimate new communalities that replace the old communality estimates in the diagonal. Iterations continue until the changes in the communalities from one iteration to the next satisfy the convergence criterion for extraction.



Extraction method

- ▶ *Unweighted Least-Squares Method.*
- ▶ A factor extraction method that minimizes the sum of the squared differences between the observed and reproduced correlation matrices (ignoring the diagonals).
- ▶ *Generalized Least-Squares Method.*
- ▶ A factor extraction method that minimizes the sum of the squared differences between the observed and reproduced correlation matrices. Correlations are weighted by the inverse of their uniqueness, so that variables with high uniqueness are given less weight than those with low uniqueness.
- ▶ *Maximum-Likelihood Method.*
- ▶ A factor extraction method that produces parameter estimates that **are most likely to have produced the observed correlation matrix if the sample is from a multivariate normal distribution.** The correlations are weighted by the inverse of the uniqueness of the variables, and an iterative algorithm is employed.



Extraction method

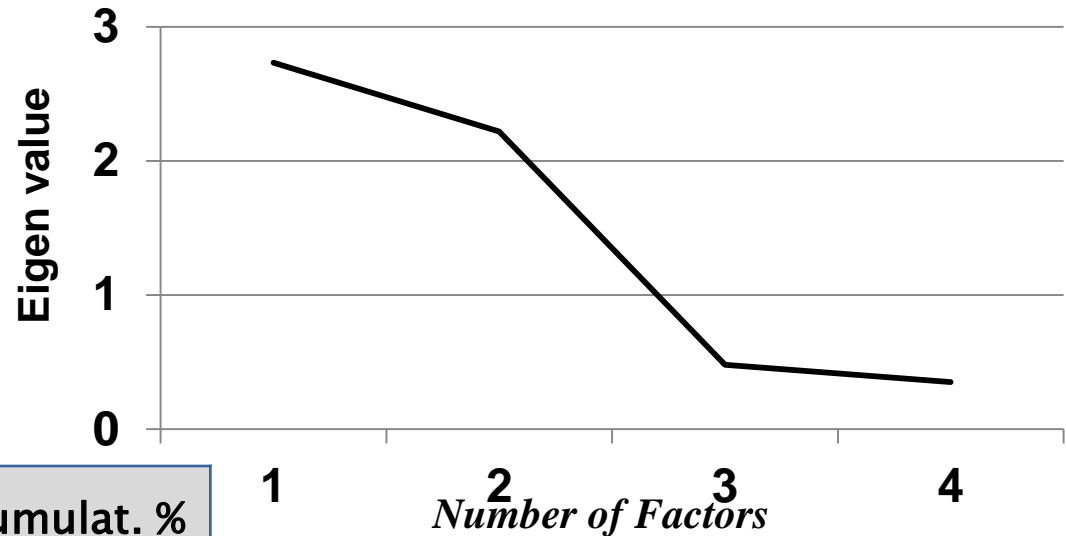
- ▶ *Alpha Factoring.*
- ▶ A factor extraction method that considers the variables in the analysis to be a sample from the universe of potential variables. This method maximizes the alpha reliability of the factors.

- ▶ *Image Factoring.*
- ▶ A factor extraction method developed by Guttman and based on image theory. The common part of the variable, called the partial image, is defined as its linear regression on remaining variables, rather than a function of hypothetical factors.



3. Choosing the number of components to extract

- ❖ A Priori knowledge.
- ❖ Determination Based on Percentage of Variance.
- ❖ Kaiser's
 - we can retain only factors with eigenvalues greater than 1.
- ❖ The scree test(Plot).



Factor	Eigen value	% of variance	Cumulat. %
1	2.71	45.52	45.52
2	2.21	36.96	82.48
3	0.48	7.54	90.02
4	0.35	2.14	92.16



4. *Rotation of Factors*

- ❖ retention is more **important** than other phases.
- ❖ facilitates **interpretation**
- ❖ A number of criteria are available to assist these decisions, but they **do not always lead to the same or even similar results**.
- ❖ After rotation each variable should have **nonzero** or **significant** loadings with only a few factors, if possible with only one.



rotation

- ▶ **Orthogonal rotation**
- ▶ Varimax
- ▶ Quartimax
- ▶ Equamax

- ▶ **oblique rotations**
- ▶ direct oblimin
- ▶ promax





دانشگاه علوم پزشکی و خدمات بهداشتی درمانی کرمانشاه

معاونت تحقیقات و فناوری

کارگاه مقدماتی مدل یابی معادلات ساختاری

(Structural Equation Model)

با همکاری گروه اپیدمیولوژی و گروه آمار زیستی

دانشگاه علوم پزشکی کرمانشاه

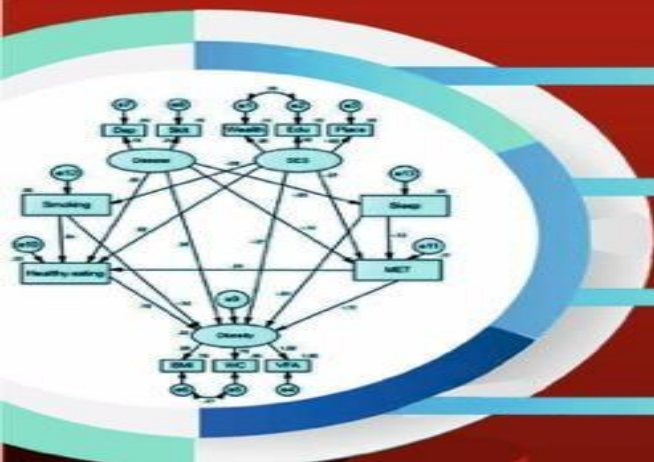
ارائه دهندگان :

دکتر فرید نجفی

دکتر مهدی مرادی نظر

دکتر شایان مصطفایی

میترا دربندی



دوشنبه ۹۹/۶/۳



۸:۳۰ تا ۱۲:۳۰



علاقتمندان در سراسر کشور می توانند از طریق آدرس اینترنتی زیر در کارگاه شرکت نمایند .

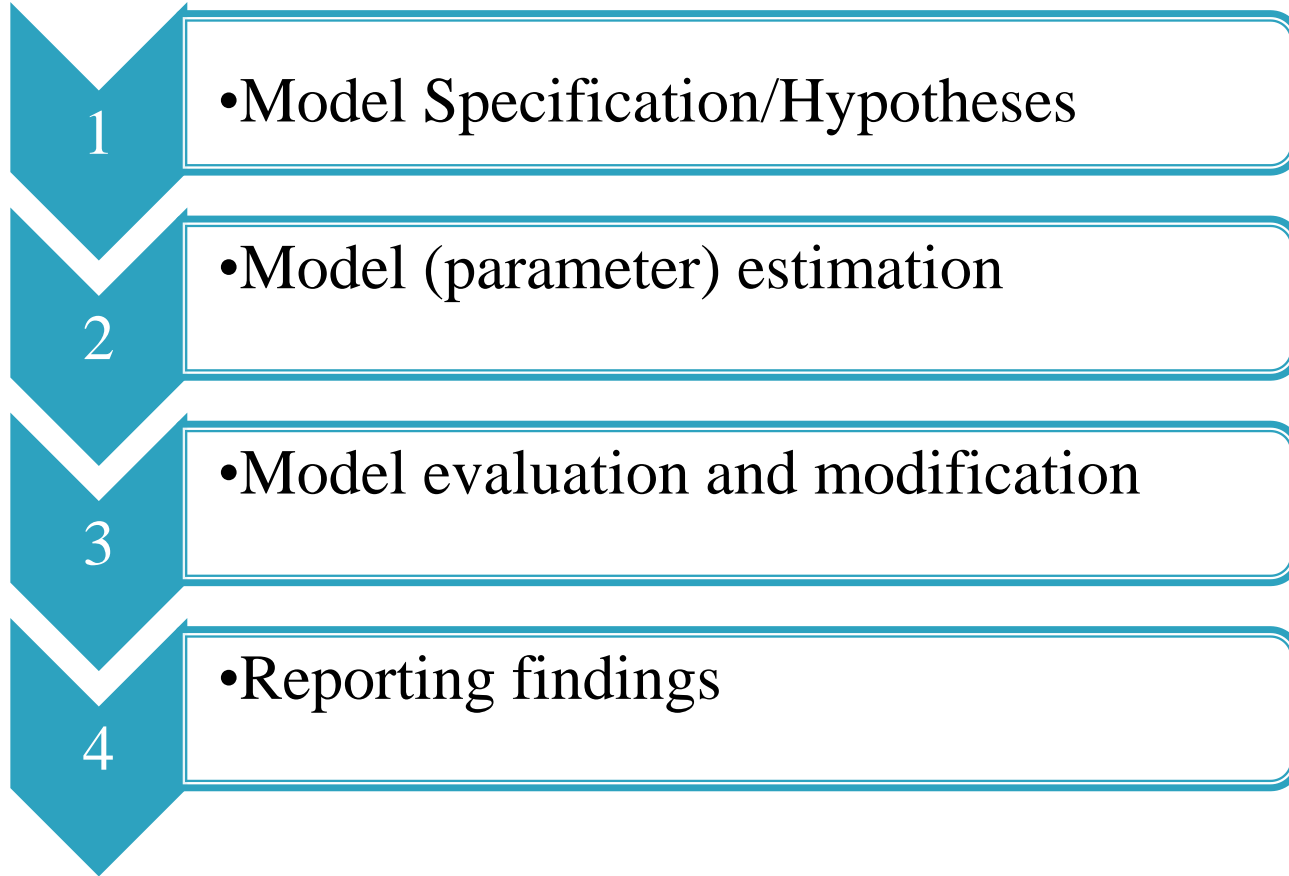
VC.Kums.ac.ir/kumsresearch

شرکت کنندگان برای اتصال نیاز به نرم افزار

Adobe connect دارند

Confirmatory Factor Analysis(CFA)

steps:



Model Specification/Hypotheses

- ▶ Specify a model derived from **theory** and a **set of hypotheses**
- ▶ Specification of the confirmatory factor model requires making **formal and explicit** statements about
 - ❑ the number of **observed variables**
 - ❑ The number of **factors**
 - ❑ **Relationship of factors to items** (which items load on which factors)
 - ❑ the **variances and covariances** among the common factors
 - ❑ **Which indicators are influenced by which factors?**



Parameter estimation:

- ▶ The parameters to be estimated (the **regression coefficients** and the **variances and the covariances** of the independent variables in the model)

- ▶ *Parameter estimation methods*

- ❑ Maximum likelihood (ML)
- ❑ Generalized least squares (GLS)
- ❑ Unweighted least squares (ULS)
- ❑ Weighted least squares (WLS)
- ❑ Diagonal weighted least squares (DWLS)



Model evaluation

Model Fit Index	Recommended Values
CMIN (Chi-square p value)	$> .05$
CMIN /df	≤ 3
CFI	$\geq .90$
GFI	$\geq .90$
AGFI	$\geq .90$
NFI	$\geq .90$
RMSEA	$\leq .05$



Determine the model fit(chi-squared test)

- ❖ chi-squared test, Values **closer to zero** indicate a better fit; **non- significant**
- ❖ researchers may fail to reject an inappropriate model in **small sample sizes** and reject an appropriate model in **large sample sizes**
- ❖ If the observed variables are **not multivariate normally distributed**, the **χ^2 test** and the **standard errors** of the parameters are biased – **but the parameter estimates are not affected.**



Goodness-of-fit index (GFI)

- ❖ The goodness-of-fit index represents the amount of **variances** and **covariances** in the sample covariance matrix **that are predicted by the model**.
- ❖ GFI can thus be interpreted **in the same way as R^2** in multiple linear regression. There is also an adjusted version, AGIF.
- ❖ **NOTE!** GFI and AGFI are very sample size sensitive, and **therefore not recommended**.



Standardized root mean square residual (SRMR)

- ❖ The **smaller** the SRMR, the better the model fit.
- ❖ Rule of thumb: **SRMR > 0.1** usually means a problem with the fit.



Comparative Fit Index (CFI)

- ❖ The comparative fit index is a normed index (range 0-1).
- ❖ with higher values indicating better model fit.
- ❖ The CFI is relatively insensitive to the complexity of the model. It is one of the most widely used indices.
- ❖ $CFI > 0.9$ or higher is usually associated with a good model fit.

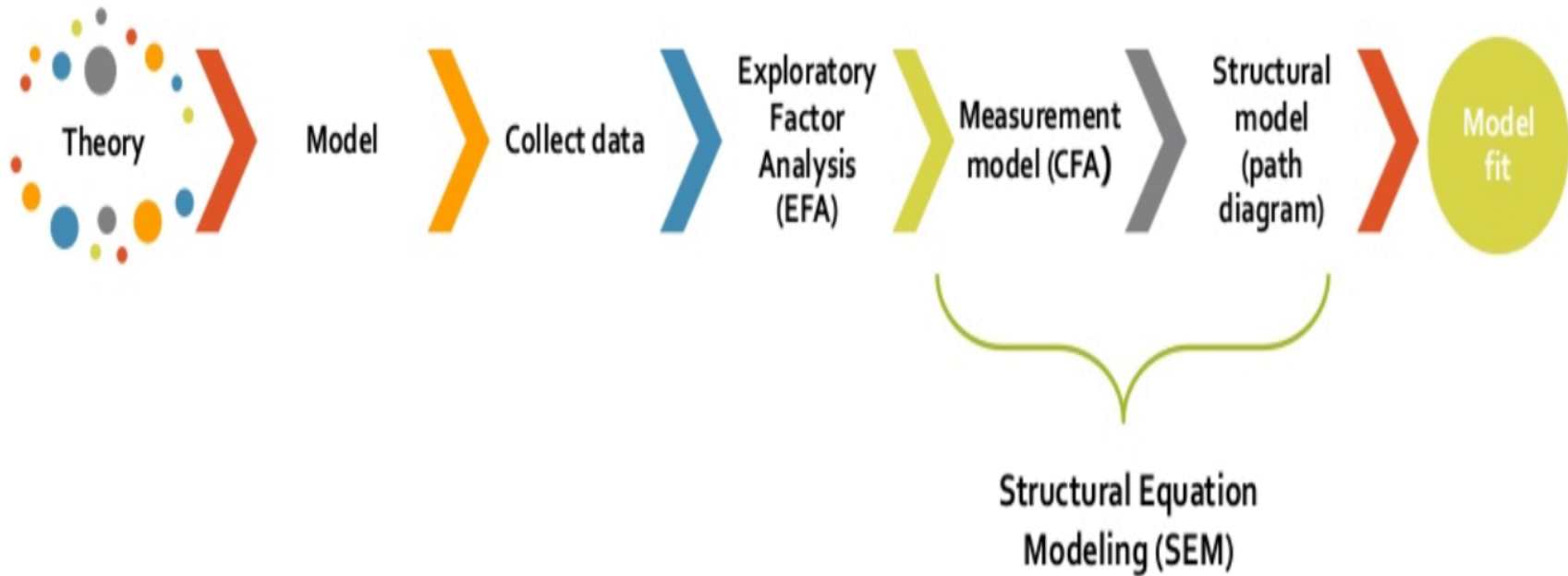


Determine the model fit base on parameter estimates

- ❖ No **correlations** or **variances** have values outside their possible range.
- ❖ If parameter estimates are outside their possible rang(**variances are negative or represent $>100\%$ of the total variance**)
- ❖ the **absolute value of correlation coefficients are > 1** , that's an indication that a model is fundamentally wrong and unsuitable for the data
- ❖ The statistical significance of the **loadings** are assessed by their **p-values**.
- ❖ Rule of thumb for a good indicator: **squared corr >0.5**



Factor analysis



❖ SEM = CFA + path analysis (regression slopes)

❖ SEM assumes causally interrelated latent variables

❖ CFA assumes interrelated latent variables (i.e. exogenous)





دانشگاه علوم پزشکی و خدمات بهداشتی درمانی کرمانشاه
معاونت تحقیقات و فناوری

کارگاه مقدماتی مدل یابی معادلات ساختاری (Structural Equation Model)

با همکاری گروه اپیدمیولوژی و گروه آمار زیستی
دانشگاه علوم پزشکی کرمانشاه

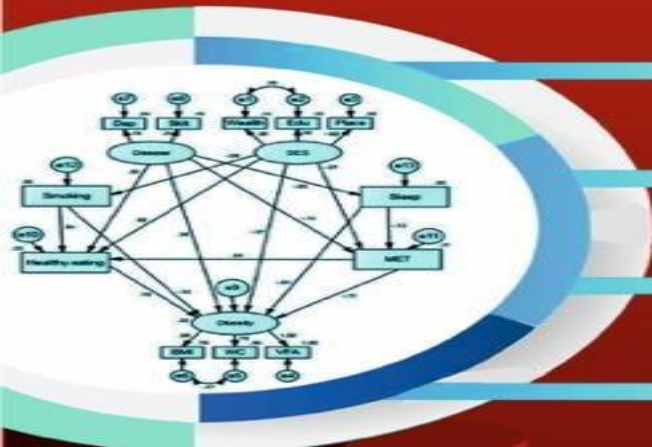
ارائه دهندگان :

دکتر فرید نجفی

دکتر مهدی مرادی نظر

دکتر شایان مصطفایی

میترا دربندی



دوشنبه ۹۹/۶/۳



۱۲:۳۰ تا ۸:۳۰



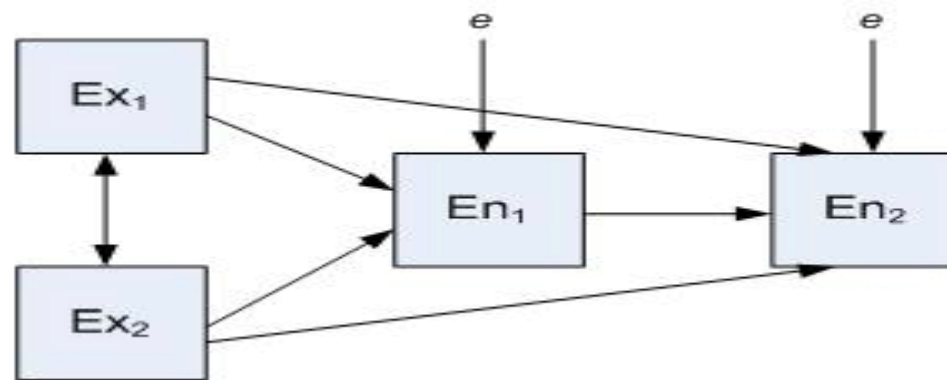
علاقمندان در سراسر کشور می توانند از طریق
آدرس اینترنتی زیر در کارگاه شرکت نمایند .

VC.Kums.ac.ir/kumsresearch

شرکت کنندگان برای اتصال نیاز به نرم افزار
Adobe connect دارند

Path analysis

- ▶ Path analysis is **special types of SEM**
- ▶ Can be used to **test causality** through the use of bivariate and multivariate regression
- ▶ Note that you are only **finding evidence for causality**, not proving it.
- ▶ Can use the **standardized coefficients** (the beta weights) to determine the strengths of the direct and indirect relationships in a multivariate model

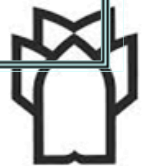
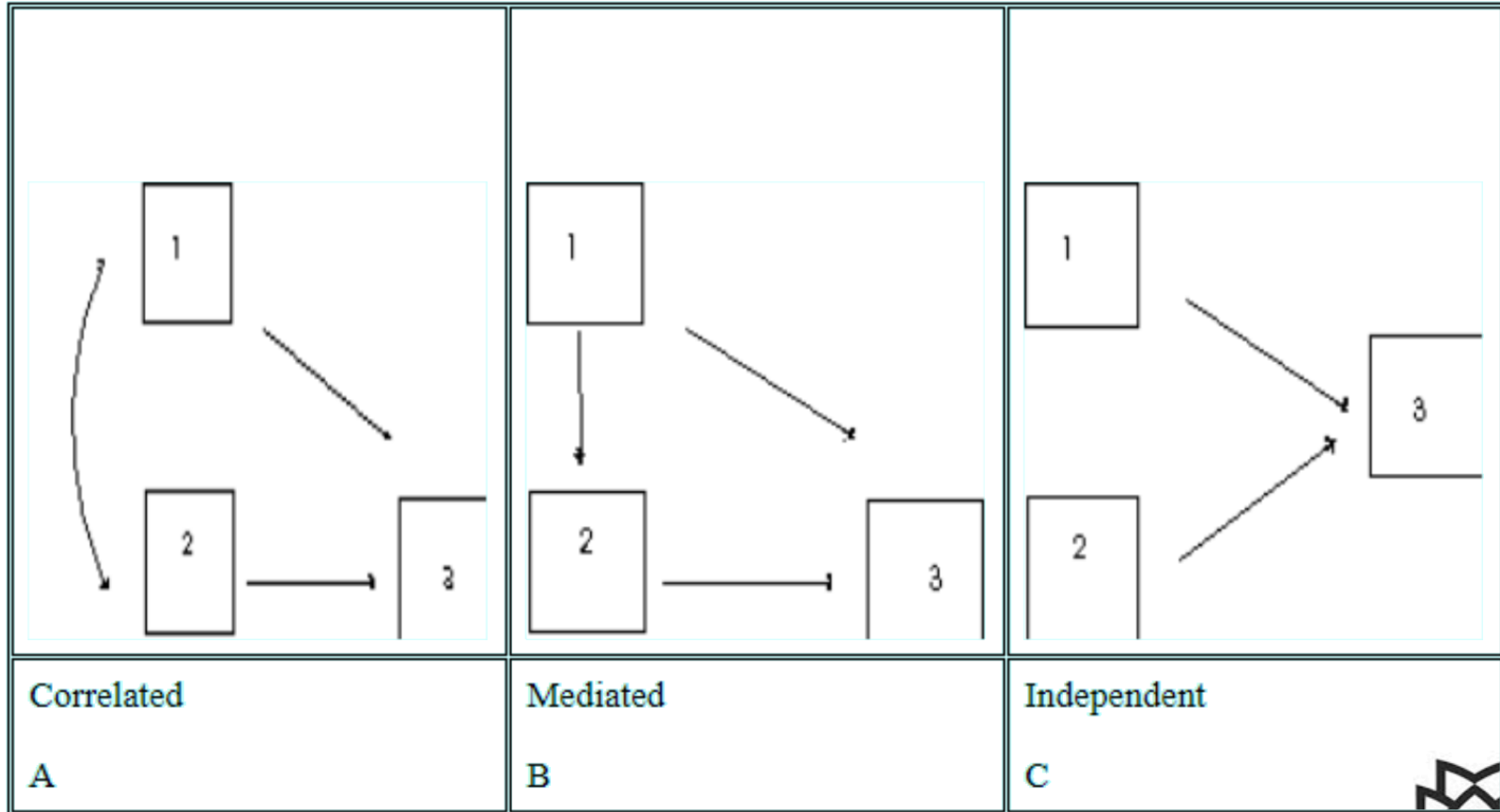


Path analysis steps

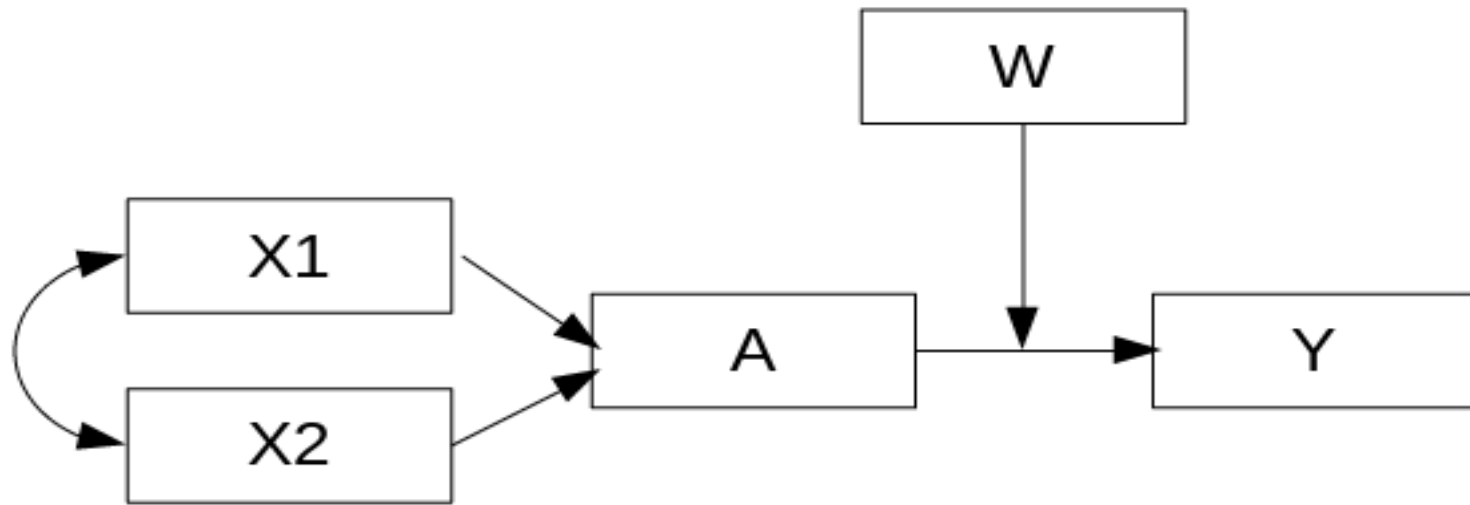
1. Draw a path diagram according to the theory.
2. Conduct one or more regression analyses.
3. Compare the regression estimates (B) to the theoretical assumptions or (Beta) other studies.
4. If needed, modify the model by removing or adding connecting paths between the variables and redo stages 2 and 3.



Path models



A Path model depicting moderation (interaction) :



There are many excellent books on factor analysis.

John C. Loehlin, A. Alexander Beaujean:

Latent Variable Models: An Introduction to Factor, Path, and Structural Equation Analysis [5 ed.]

Mindrila, Diana:

Education in a competitive and globalizing world series. Exploratory Factor Analysis: Applications in School Improvement Research

Jason W. Osborne, Erin S. Banjanovic

Exploratory Factor Analysis with SAS

Timothy A. Brown:

Confirmatory Factor Analysis for Applied Research

Donna Harrington

Confirmatory Factor Analysis (Pocket Guides to Social Work Research Methods)

