MULTIVARIATE STATISTICS

Chapter 1: What is it?

Content

1. What is Multivariate Analysis?
2. Measurement Scales
3. Hypothesis Testing
4. Error and Power Defined

1. What is Multivariate Analysis?

Multiple variables that, when examined together, provide a more meaningful interpretation than when examined separately (univariate) or in pairs (bivariate).

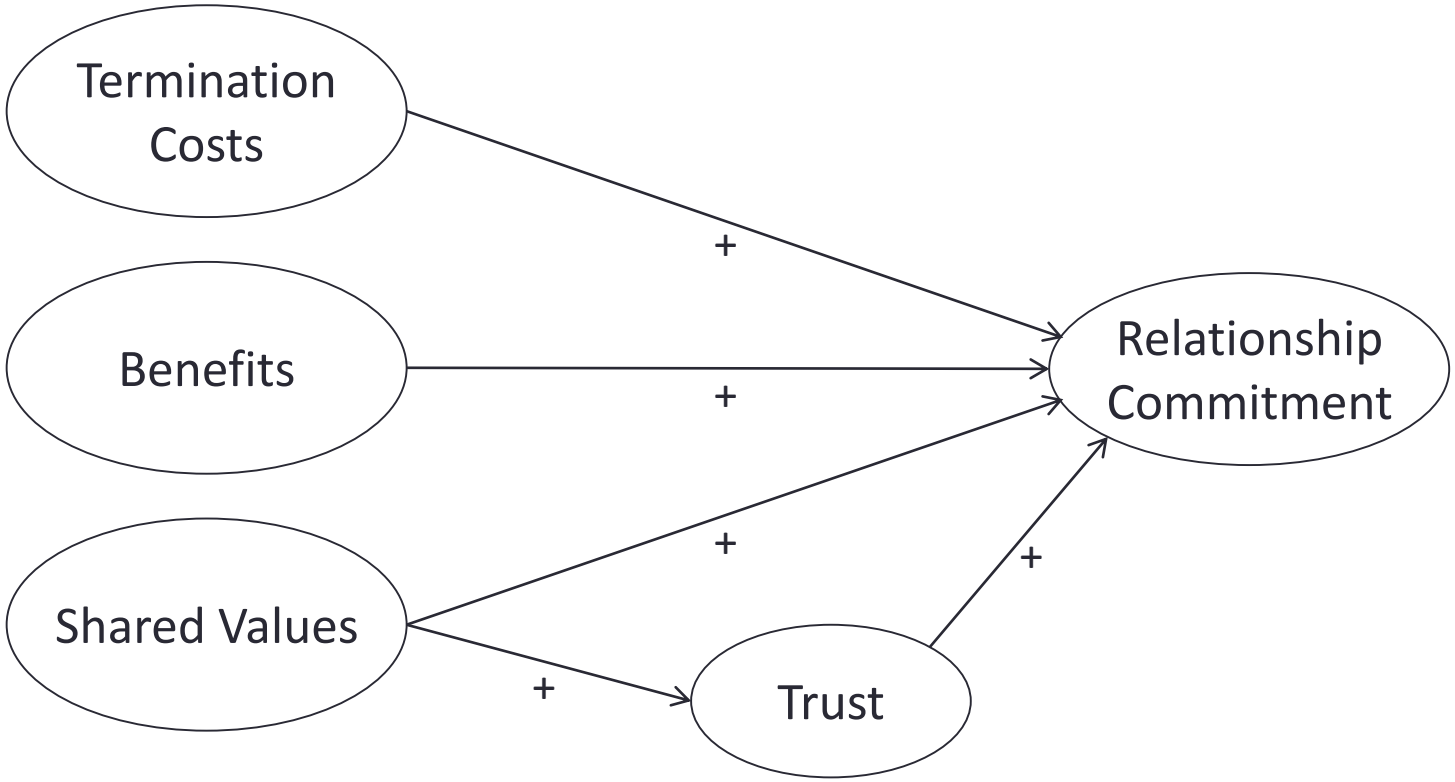
Example:

Relationship Commitment = f (Termination Costs + Benefits + Shared Values + Trust)

Versus:

- Relationship Commitment = f (Termination Costs)
- Relationship Commitment = f (Benefits)
- Relationship Commitment = f (Shared Values)
- Relationship Commitment = f (Trust)

Commitment-Trust Theory



2. Measurement Scales

Measurement: Rules for assigning numbers to objects in such a way as to represent quantities of attributes.

- Nominal (male-female)
- Ordinal (education level)

} Non-parametric (Nonmetric)

Ordinal?

} Metric?

- Interval (temperature)
- Ratio (units sold)

} Parametric (Metric)

Rule of Thumb!

Always measure at the highest level possible.

e.g. Age _____ Calculate the average.

Age
- 0-20 ☐
- 21-40 ☐
- 41-60 ☐
- >60 ☐

Calculate the average?

Rule of Thumb!

Always measure at the highest level possible.

e.g. Beer _____

Beer 0-20 ☐

21-40 ☐

41-60 ☐

>60 ☐

Measurement Error

Measurement error is the degree to which the observed values are not representative of the ‘true’ values.

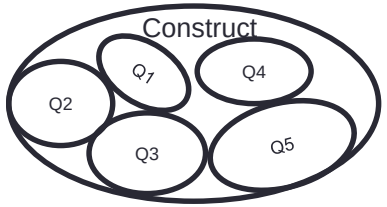
What is the true value of learning?

(behavioral or cognitive)

You need a theoretical definition, and some sort of operationalization that corresponds with the theory.

6.2 Constructs and Operationalization

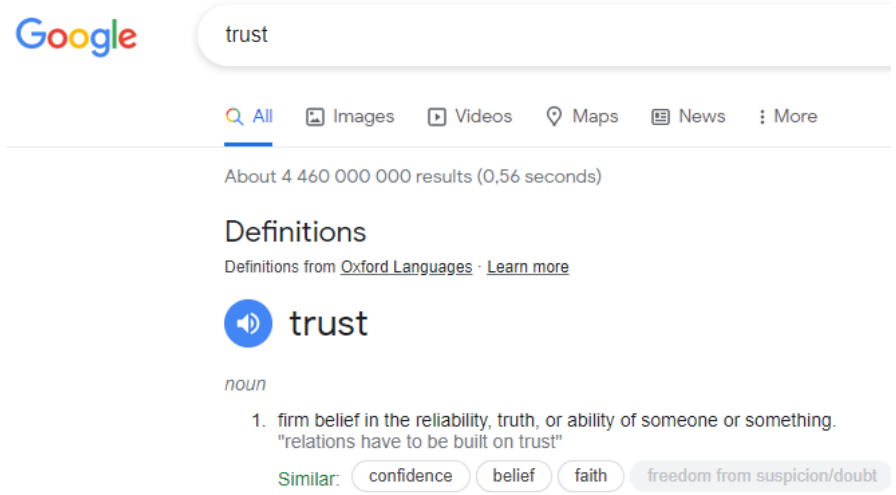
A construct is formulated so it can be measured; its primary purpose is to delineate a domain of attributes that can be operationalized and preferably quantified as variables.

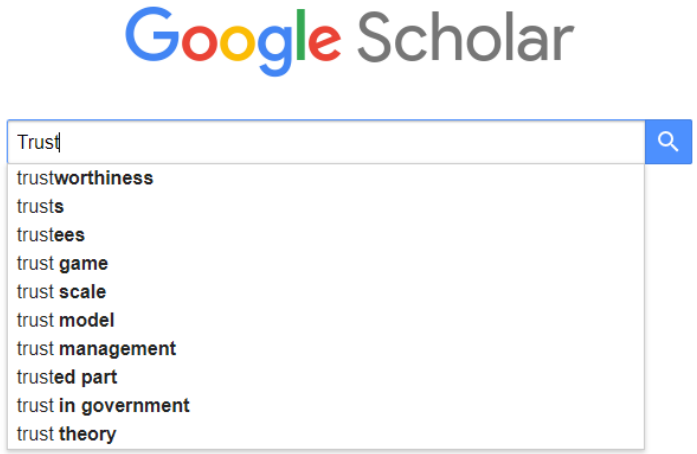


Do you trust me?

No 1 2 3 4 5 6 7 Yes

Construct Definition - What is trust?





ADVICE:
When writing a scientific paper, try to find existing theoretical definitions of your core constructs.

If you want to measure the construct, try to find existing scales!

Why? (next slide)

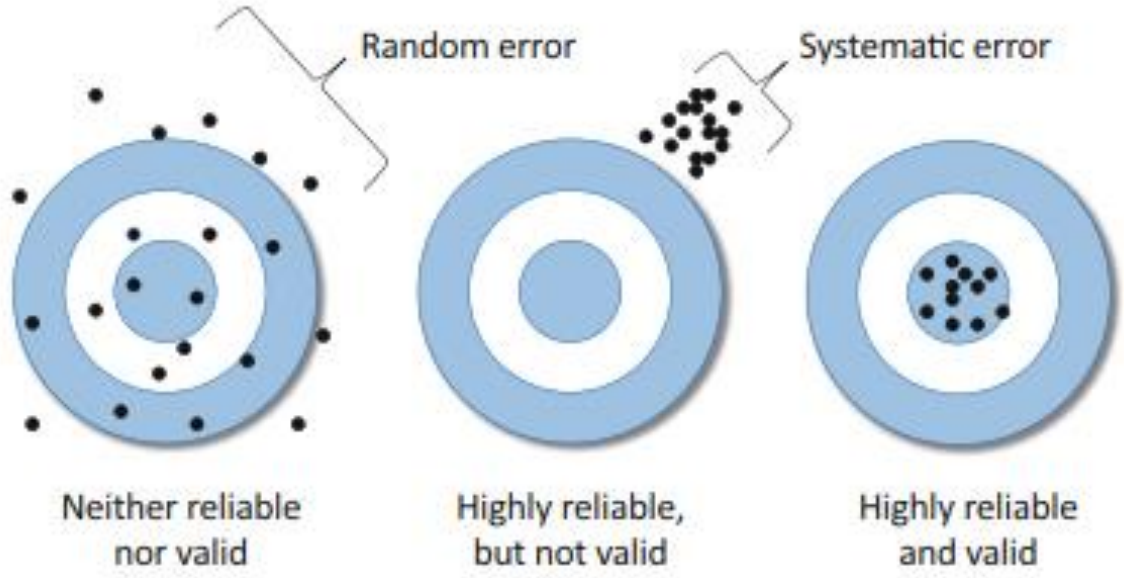


Fig. 3.7 Validity and reliability

Validity refers to how well we measure what we intend to measure.

Reliability refers to the consistency of how well we measure something.

What are we measuring?

On a 1-7 scale anchored:

Completely disagree 1 2 3 4 5 6 7 Completely agree

1. I trust that the other organization is able to fulfill contractual agreements.
2. We trust that the other organization is competent at what they are doing.
3. There is general agreement in my organization that the other organization is trustworthy.

Multiple Measures

- Multivariate measurements … summated scales … composite measurement … aggregated scales …

- Would you let a researcher measure your intelligence with just one question?

Rule of Thumb!

In general, multiple measures more accurately represent the true value of a construct.

Validity and Statistics

Internal validity.

External validity.

} Related to the argumentation and sampling.

Construct validity:

- Convergent validity
- Discriminant validity

} Related to the measurement instrument (multiple measures).

Content validity.

} Related to multiple measures.

3. Hypothesis Testing

For every hypothesis there is at least one implicit alternative hypothesis.

- The null hypothesis (not usually shown) is often what you don't want.
  - H_0: Shared values do not affect trust.
- When you suggest that two constructs are significantly related, you have a two-sided hypothesis.
  - H_A: Shared values affect trust.
- When you suggest that two constructs are positively (or negatively) related, you have a one-sided hypothesis.
  - H_A: Shared values positively affect trust.

(Kalwani and Narayandas 1995). As one supplier stated in the field interviews: "We have restructured the entire operation. We customize our products for every customer, so in that sense we make changes based on what we learn about what they want."

A potential problem may be that relationship learning results in incorrect insights and thus might actually reduce performance. The relationship partners learn to do the wrong things right or the right things wrong. In such situations, unlearning might be the only way to increase performance (e.g., Hedberg 1981). However, we believe that, in general, relationship learning has a positive effect on the performance of the relationship.

Alternative hypothesis

H_1: Relationship learning has a positive effect on relationship performance.

Relational Trust

Relational trust is the perceived ability and willingness of the other party to behave in ways that consider the interests of both parties in the relationship, and mainstream thinking states that trust is a facilitator of effective cooperative behavior in customer–supplier relationships (e.g., Dwyer, Schurr, and Oh 1987). The primary rationale for enhanced performance is that high levels of trust reduce reliance on formal control mechanisms, which thereby reduces transaction costs (MacNeil 1980; Nooteboom, Berger, and Noorderhaven 1997). Dwyer, Schurr, and Oh (1987) develop a framework for how interorganizational relationships start, evolve, and dissolve. Central to the development and maintenance of relationships is the establishment of norms of conduct that allow for future exchange and increased risk taking in the relationship. The most fundamental norm is trust, which provides the foundation for understanding expectations and for cooperation in the relationship. Thus, we expect relational trust to enhance relationship performance.

Alternative hypothesis

H_2: Relational trust has a positive effect on relationship performance.

of trust is usually accompanied by strong, positive emotions and liking (Jones and George 1998). In such atmospheres, a risk exists that negative or critical information is not exchanged because it might endanger the good atmosphere of the relationship. Thus, the benefit of constructive conflict is lost (Eisenhardt, Kahwajy, and Bourgeois 1997). High levels of trust might also produce a lack of critical information search. Alternatively, parties might take advantage of trust and exploit the other party in opportunistic ways (Hamel 1991). Opportunism in the form of self-seeking behavior might also cause high-trust relationships to be less effective (Grayson and Ambler 1999). In addition, as commitment increases, value systems converge and the parties develop a common identity (Gaertner, Dovidio, and Bachman 1996). They might become too homogeneous, which hinders the creative processes found in more heterogeneous groups, as with Janis's (1989) groupthink. Moorman, Zaltman, and Deshpandé (1992) suggest that this reduces the ability to be objective within the relationship, which thus diminishes the capacity to question assumptions on which actions are based.

Thus, high levels of trust might have "hidden costs" that limit the effectiveness of working relationships. We therefore propose that the general positive effect of relationship learning on performance is lower under conditions of high trust. Because these costs are hidden, the parties are not necessarily aware of the negative consequences of their mutual and high levels of trust. This implies that when relationship learning is least costly to initiate, that is, under high levels of trust, it is less effective than under lower levels of trust, and vice versa.

Alternative hypothesis

H_4: The positive effect of relationship learning on relationship performance is moderated (reduced) under conditions of high trust.

Collaborative Commitment

Central to organizational-learning theory is the notion of the capability to learn, and it is suggested that this capability is related both to a commitment to learn (Day 1994a) and to a

Rule of Thumb!

The more specific the hypothesis, the stronger the test of the theory.

Money in the bank

- Supported strong hypotheses provide more money.

Damn strange coincidence

- Not supported strong hypotheses are less of a coincidence.

You have to compare your bank balance with your damn strange coincidences.

4. Error and Power Defined

Type I error (α): The probability of rejecting H_0 when actually true.

Inversely related, i.e. You have to make a tradeoff.

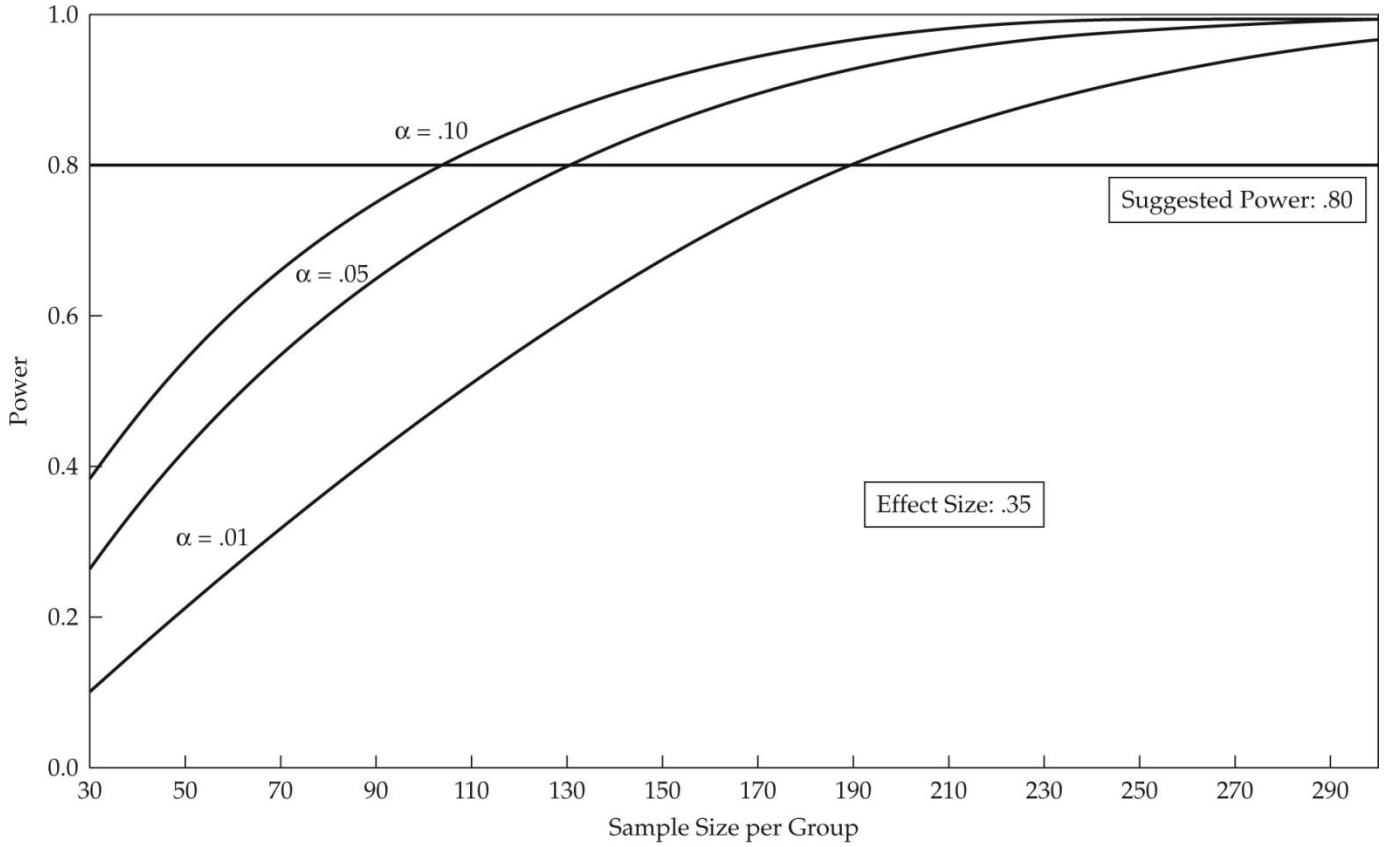
Type II error (β): The probability of not rejecting H_0 when actually false.

- **Power** = 1 - β: The probability of correctly rejecting the null hypothesis when it should be rejected.
  - F (effect size + alpha + sample size)

Image source: unbiasedresearch.blogspot.com

Power

Power = F (effect size + alpha + sample size)



Rule of Thumb!

- In general, use alpha at 0.05.
  - In economic applications it is safe to use 0.1 - 0.01.
  - Remember, this is not an exact science, so use common sense when interpreting significance.

- For sample size, consider which technique you are using and refer to the literature for guidelines.

- Evidence-based medicine (business) ☺
- Meta analysis

Structured Approach (Pirate Code)

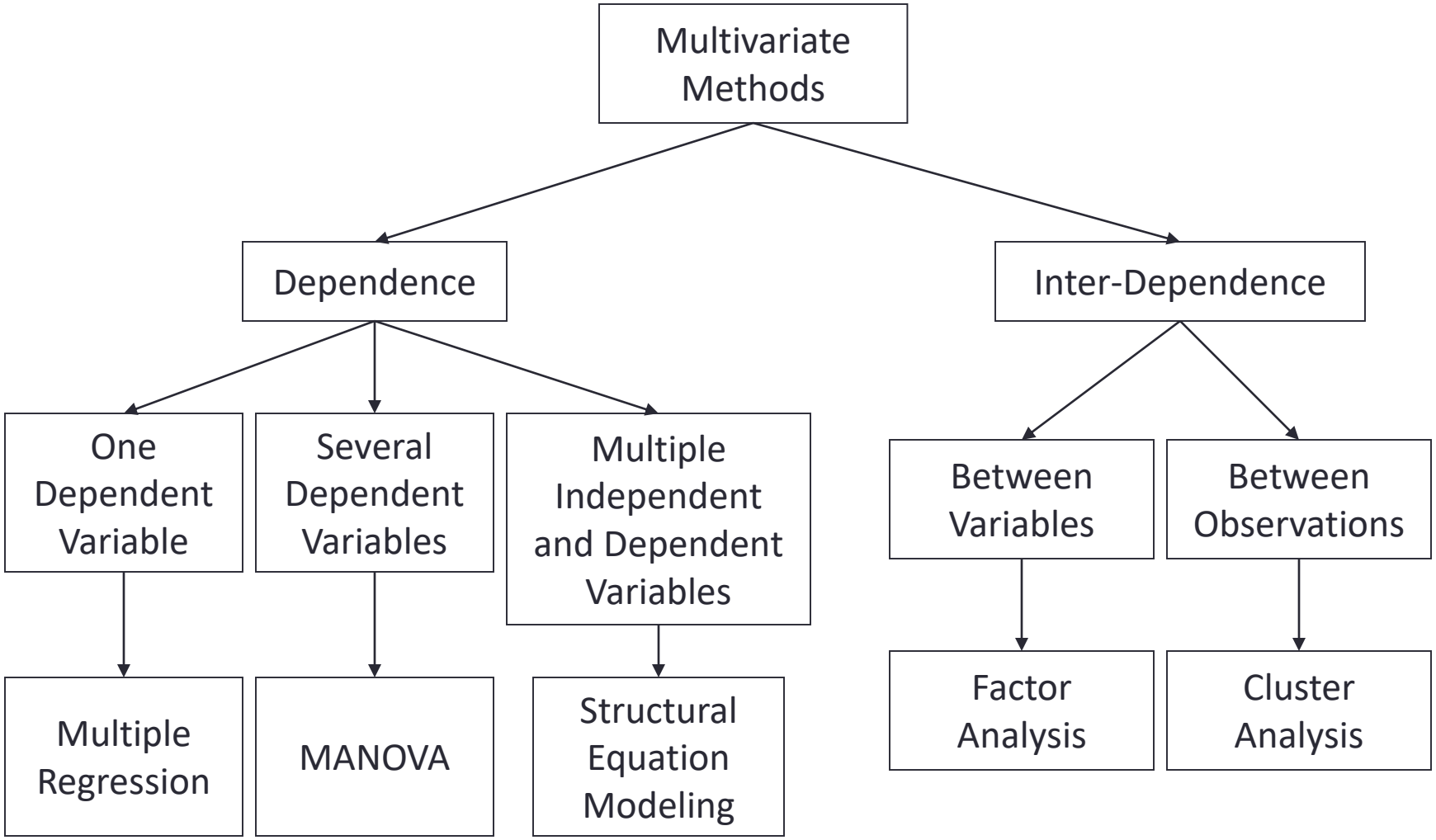
1. Define the problem.
2. Develop a plan (design).
   - Strive for parsimony.
3. Evaluate the underlying assumptions of the multivariate technique.
   - Look at outliers, normality, missing data, etc.
4. Estimate and assess the model.
   - Look at errors.
5. Interpret the results.
   - Use common sense, sell your strengths, justify your weaknesses.
6. Validate the results.
   - Consider practical and statistical significance.

Choice of Analysis Technique

The appropriate technique depends on:

- Research design.
- Type of data:
  - (nominal, ordinal, interval, ratio).
- Assumptions underlying the test statistic.

Decision Tree



Rule of Thumb!

Statistics is based upon sound, rigorous argumentation and logic:

- Establish practical as well as statistical significance (so what?).

- Sample size affects all results:
  - Small may not detect significant results.
  - Small may ‘overfit’ the data in that the results are fluke and specific to that data set – no generalizability.
  - Big may detect everything as significant.

Continued

- Know your data (outliers, normality, nonlinearity, interaction, …).
- Consider control variables.
- Strive for parsimony, but avoid specification error.
- Look at errors to lead you on.
- Validate your results (split/new sample, bootstrapping).