Quantitative Social Research Methods

Ben Daniel, PhD

Senior Lecturer & Coordinator of Educational Technology
Higher Education Development Centre (HEDC)

University of Otago
Dunedin, NEW ZEALAND
ben.daniel@otago.ac.nz
Today’s Agenda

• Review of basic concepts
• Formulating research project
• Measurement
• Quantitative design
• Methods for data collection

Break
• Sampling
• Hypothesis testing
• Analysis
• Reporting
Goals

• This workshop focuses on the design of a quantitative research project

• Participants go through the problem formulation, project design, data collection, data analysis and reporting

• The workshop will review the basic analytical techniques and commonly used statistical models for data analysis
Review of Basic Concepts
What is Research?

• A systematic and logical process of searching for knowledge through the use of data

• It is a process of resolving a problem, or an attempt to gain a greater understanding of a phenomenon

• Collectively, the process involved in attaining the first goal or second or both is often called research methodology
Research Philosophy

Ontology: Basic assumptions about the nature of reality

Epistemology: Basic assumptions about what we can know about reality, and about the relationship between knowledge and reality

Paradigm: Overarching perspective concerning appropriate research practice, based on ontological and epistemological assumptions

Methodology: Specifies how the researcher may go about practically studying whatever he / she believes can be known
Basic Paradigms in Social Science Research

Three basic paradigms

- Positivism
- Interpretivism
- Constructionism
Logic of Research

Inductive Reasoning

Tentative Hypothesis

Theory

Pattern

Observation

Deductive Reasoning

Hypothesis

Observation

Confirmation

Theory
Two Ways to Classify Research

- Applied
- Basic
- Research
Quantitative Research

- Quantitative research involves a systematic empirical investigation of phenomenon

- It includes a wide variety of laboratory and non-laboratory procedures

- The process involves numerical analysis and measurement of constructs

- Statistics, tables and graphs, are often used to present the results
Core Quantitative Research Concepts

• Research language is made of certain core concepts, some of these include:
  − A variable is an entity or a thing that can take different finite or infinite values, e.g. age, language, etc.
  − Variables have attributes e.g. 20, 30, 40; English, French, etc.
  − Attributes are specific values of a variable
  − In research variables have finite properties, they are either dependent or independent

• Dependent variable:
  − The secondary variable affected by the independent variable e.g. the outcome of research treatment

• Independent variables:
  − A primary variable that the research manipulates against another variable e.g. a program, a course, a language, a culture etc.
Performing Quantitative Research
Quantitative Research Methodology

Formulation Phase

Design & Implementation Phase

Research Methodology

Analysis & Conclusion Phase
Formulation Phase

- Identifying a research need
- Defining the problem
- Developing questions and objectives
- Specifying hypotheses
- Performing literature review
- Developing theoretical model
Research Question/Goal

• Defining a research question/goal involve answering five basic questions
  • Who, Where, When, What, and How
• It also involve the ability to assess answers in relation to whether they are:
  • right for the question/goal,
  • suitable to the researcher,
  • Practical
  • Doable
Key questions when formulating research statements

**What**
- What will you look for?
- What will you ask?

**Who**
- Who do you plan to speak to/ observe?
- What do you want to be able to speak about or observe?

**Where**
- What is the domain of your sample?
- Are settings relevant to the credibility of your methods?

**How**
- How will you collect your data?
- How will you conduct your methods?

**When**
- What time have you got?
- How do your methods fit into your timeframe?
- Is timing relevant to the credibility of your methods?
Type of Research Questions

• The three research question types can be viewed as collective and intertwined with types of research studies

1. Descriptive questions aimed at describing a specific phenomenon (e.g. single case)

2. Relational questions examine relationships between two or more variables

3. Causal questions are concerned with relationships among variables and possible directions or causes of the relationships
Problem Statement and Hypotheses

• **A problem statement is:** a clear and concise description of the issues the researcher(s) needs to address

• **A research question is:** a statement that identifies the phenomenon to be studied

• It must clearly define the domain, the variables, and their relationship

• **A hypotheses is:** a specific statement of prediction described in terms what a researcher expects will happen in a study

• An hypothesis is either expressed as a true hypothesis or null hypothesis
Measurement and Scales

- Measurement is also a process of assigning numbers or symbols to characteristics of objects based on pre-specified rules.

- It involves observing and recording the observations in a research study.
Caution!

• Researcher do not measure the object, person, state or event, but characteristics of the object.

• Numbers are normally used to represent the observable/unobservable characteristics.

• Rules specify how the numbers are to be assigned to the characteristics.

• Measurement determines appropriate statistical analysis on the values that were assigned.

• It guides interpretation of the data from that variable.
The Measurement Process

1. Defining Constructs
2. Defining Attributes
3. Selecting a scale of measurement
4. Generating Items
5. Developing an instrument
6. Pretesting the instrument
Example of Construct of Attitude

- A learned tendency to respond in a consistently favorable or unfavorable manner toward something
- Three key components:
  - **Cognitive:** A person’s beliefs or perceptions about something
  - **Affective:** An individual’s positive or negative feelings toward something
  - **Behavioral:** A person’s behavioral intention toward something

The relationship of the values that are assigned to the attributes for a variable (construct)
The Levels of Measurement

• The level of measurement refers to the way a particular variable is measured.

• Familiarity with the level of measurement of the variables in your data set helps determine appropriate statistical procedure.

• There are four main levels of measurements:
  – Nominal
  – Ordinal
  – Interval
  – Ratio
Nominal Measurement

• Nominal level of measurement—classifies data into names, labels or categories in which no order or ranking can be imposed.
  – Example—the names of courses offered in a department

• Martial status
  – ___ Married  ___ Single  ___ Single, never married  ___ Widowed

  – Statistics use—mode and frequencies
Ordinal Measures

• A ranking measures in which numbers are assigned to objects

• Ordinal measures have counting operation similar to nominal scale data

• Attributes are orderly ranked but distances between attributes do not have any meaning
  – E.g, code Educational Attainment coded as:
    0=less than H.S.; 1=some H.S.; 2=H.S. degree; 3=some college; 4=college degree; 5=post college

• Ordinal measures permit the use of statistics based on e.g. mode, median, etc.
Interval Scale

- Interval level of measurement—ranks data, precise differences between units of measure exist, but there is no meaningful zero
  - E.g. temperature is an interval variable because the distance between 30 and 40 degrees Fahrenheit is the same as the distance between 70 and 80 degrees Fahrenheit.
  - The interval between the values is interpretable
  - For this reason averages, or means are computed
Ratio Measurement

• Ratio level of measurement—has all the characteristics of the interval level, but a true zero exists

• Can construct a meaningful ratio (fraction)
  – Example—weight of an individual (it makes sense to say that a 150 lb adult weighs twice as much as a 75 lb. child
The Hierarchy of the Measurement Levels

- **Nominal**: Attributes are only named; weakest
- **Interval**: Attributes can be ordered; distance is meaningful
- **Ratio**: Absolute zero; attributes are only named; weakest
- **Ordinal**: Journey of measurement starts here

*NOIR*—[Run Into Open Net]
Measurement Issues

- Measurement in quantitative research should fulfill objectivity, validity, reliability, accuracy and precision
  - **Validity** – approximate truth in measuring a construct
  - **Objectivity** - researchers stand outside the phenomena ensuring data is not bias
  - **Reliability** - ensuring instruments measuring a phenomenon produce same results when replicated
  - **Accuracy** – credible methods for collecting relevant data
  - **Precision** – trustworthiness and confidence in results
Literature Review: Guiding Questions

• Researchers review the literature to develop a theoretical framework

Source: adapted from Hart (1998)
Group Activity 1

1. Develop a research question
2. Develop a research statement
3. Develop a hypothesis
4. Is there an IV and a DV?
5. How would you measure your variables?
Discussion—Break
Design and Implementation Research Project
Design and Implementation Phase

• A research design is a glue that holds a research project together
  − It shows how all of the major parts of the research project work together in addressing central research questions
  − Provides a framework for collecting and analysing data

• The design phase deals with:
  − How data will be collected
  − How data will be analyzed
  − How research results will be achieved
Quantitative Research Design

- Descriptive
- Quasi-experimental
- Correlational
- Experimental
Descriptive Research Design

• Exploration and description of phenomena in real-life situations
  – E.g international students academic experiences at the SUZA
  – Exploring spread of influenza among a certain population
  – Highway accidents before and after increasing the speed limit

• New meaning is discovered and the description of concepts is accomplished

• Helps to identify relationships

• Best methods for collecting information that will demonstrate relationships and describe the world as it exists

• These types of studies are often done before an experiment to know what specific things to manipulate and include in an experiment
Correlational Design

• Looks at the relationship between two or more variables
  – E.g. exercise and the rate of heart attacks in certain group of people
  – Number of years studying and salaries earned
  – Temperature and the sales of ice-creams

• Correlational/relational design studies determines the strength
  and type of relationships

• No cause and effect assumed
Quasi-experimental Design

• An experiment is quasi-experiment (quasi = seeming, resembles)
• Quasi-experiments are referred to as natural experiments
  – because membership in the treatment level is determined by conditions beyond the control of the experimenter (subjects already differ in some natural dimensions, age, gender etc.)
  – Investigating the effects of alcohol consumptions among pregnant women
• Subjects are not randomly assigned to the treatment condition
• Less control by researcher than true experimental designs
• Examines cause-and-effect relationships
Experimental Research

• The word empirical means information gained by experience, observation, or experiment

• It also implies working with an hypothesis that can be tested using observation and experiment

• Looks at cause-and-effect relationships
  − E.g. a doctor treats a patient with a skin condition with different creams to see which cream is more effective
  − A teacher implementing a new teaching method in classroom

• Main characteristics:
  − Controlled manipulation of at least one independent variable
  − Uses experimental and control groups
  − Random assignment of the sample to the experimental and control groups
Key Methods of Data Collection

• In quantitative research methods for data collection depends on the research question

• Common methods include:
  • surveys, interviews, tests, physiological assessments, observations and biological samples
Survey Methods

• Surveys are widely used in quantitative design

• A Survey involves collecting data from a sample of people using an interview or questionnaire

• A survey can also be administered in person, through the mail, telephone or electronically (e-mail or Internet)
Observational Methods

• Observations involves watching participants engaged in routine behaviors
• Observation include formal and informal patterns of interaction among people, animals
• Unstructured observation – describing what occurs
  – Researcher usually does not have a preconceived idea about what would occur.
• Semi-Structured observation using a checklist to record what is observed.
  – Requires that you have an idea about what will be found.
• Structured observation
  – Starting with an operational definition of what needs to be measured
Biological Methods

• Biological samples are substances (blood, urine, saliva) that are taken from an individual and used to measure physiological information
  – An example would be drawing blood to assess the sugar content in a diabetic patient
Psychological/Cognitive Tests

- Different types of tests are used in research to determine a participant's aptitude, knowledge, health, or mental status as compared to the general population.
- A participant's performance on the test is then compared to these standards and/or correct answers.
- Tests can be administered in person or through a paper or electronic medium.
  - An example of common tests in education would be students taking a standardized test for academic achievement (e.g., TOESL, GRE, etc.).
Physiological test

• Physiological assessments are measurements in which a participant's physical characteristics

• Clinicians use physiological assessment may be used to determine the participant's health status prior to, during, or after the completion of the study
  – For example a clinician would assess a patient’s blood pressure, heart rate, or physical strength
  – Or asking older adults touching their toes to assess flexibility and reach.
Group Activity 2

• In reference to your Group tasks 1 identify an appropriate research design and discuss its relevance to the questions you are pursuing
• What kinds of data would you be collecting?
• What methods would you employ to collect data and why?
Sampling and Sampling Theory
Sampling

- Sampling is the procedure used to gather people, places, or things to study.
- Researchers mostly study a sample instead of a population.
Population and Sample—A Relationship

- A population is the entire collection of people or things a researcher is interested in
  - It is measured in parameters—a value that represents a certain quantifiable characteristic of a population

- A sample is a subset of a population
  - A statistic is a value calculated from a sample of data
How to Draw a Sample

Step 1: Define the Target Population
Who do you want to generalize to?
The Theoretical Population

Step 2: Identify the Sampling Frame
What population can you get access to?
The Study Population

Step 3: Select a Sampling Method
How can you access them?
The Sampling Frame

Step 4: Determine the Sample Size
Who is in your study?
Your Study Sample

Step 5: Select the Sample Elements

Step 6: Collect the Data from the Designated Elements

Define the Target Population
Identify the Sampling Frame
Select a Sampling Method
Determine the Sample Size
Select the Sample Elements
Collect the Data from the Designated Elements
Sampling Techniques

- Probability Sampling
  - Simple random
  - Stratified random
  - Cluster
  - Multistage

- Non-Probability Sampling
  - Convenience
  - Haphazard
  - Quota
  - Snowball
Simple Random Sampling

• Simple random sampling provides – equal chance of anyone in the sample being chosen

• **Randomization**: a technique for insuring that any member of a population has an equal chance of appearing in a sample
  
  – With randomization, sample statistics will *on average* have the same values as the population parameters
  
  – It can be employed to select those not in the target group – indiscriminately
  
  – It may require large sample size to be representative
  
  – It can be very expensive and often the most abused sampling technique
Selecting a Simple Random Sample

1. List all the subjects in a population
2. Assign a number to each subject
3. Pick numbers from a list of random numbers
4. Put the corresponding subjects in the sample
5. Cost and feasibility can be problems, especially if the population is large
Stratified Random Sampling

• Samples are drawn on the basis of a representative segment
  − subjects are initially grouped into different classifications such as age, socioeconomic status, etc.
  − E.g. pre-planned number of subjects in specified categories (e.g. 100 men, 100 women, 50 age <30; 50 age 30>)

• Sometimes referred to as segment/quota random Sampling
• Still uses random approach but more focused
• More focused on proportions
Cluster Sampling

- Cluster sampling is based on geographical/physical areas or ‘clusters’ representative of the whole population
- It is used when "natural" groupings are evident in a population
  - Normally a researcher first identifies boundaries, e.g. residential areas, or cities
  - Then researcher randomly selects a number of identified areas
  - The researcher can either include all the individuals within the selected areas or randomly select subjects from the identified areas
Multi-Stage Sampling

• Requires the combination of several sampling techniques and random stages
• It is aimed at creating a more efficient and effective sample than the use of only a single sampling technique
  – For example, if you are interested in studying parents attitude to home schooling in Unguja you can apply multi-stage sampling:
  – First divide Unguja into geographical clusters—regions, cities etc.
  – Choose a sample from each region or city or town using simple random sampling—X residents
  – Choose participants to interview from each chosen sample etc.
• The technique is useful if the population is very large
What is an Ideal Sample Size for Quantitative Studies?

• The size of the sample depends on
  – the type of research design being used
  – depends on the desired level of confidence in the results
  – and the characteristics of the population of interest
  – desired effect size
  – In general, larger sample size is required to study more diverse/heterogeneous population

• Desired precision: need larger sample to get smaller sampling error
• Sampling strategy: smaller if stratified, larger if clustered
The Analytical Phase
The Analytical Phase: Data Analysis

• Data analysis is the processing of interpretation of research findings
  − It is where the data is summarized
  − Useful information is presented
  − Conclusions are drawn
Analytical Phase: Types of Data

• Expressed in numerical forms
• Summarized in form of graphs, statistics, bar charts, histograms, frequency distribution tables, etc.
• Data are used to classify groups
  – Examples; numbers, quantity, prevalence, incidence.
  – Variables can be classified as physical (population, infrastructure), social (poverty), spatial, socioeconomic factors, etc.
Descriptive vs. Inferential

• Descriptive statistics summarize your data and simply tell you about the distribution or location of averages within a given sample.

• Inferential statistics use the theory of probability to estimate the differences between your sample and population.
Summary of Descriptive Statistics

Summary Measures

Central Tendency
- Median
- Mode

Variation
- Range
- Variance
- Standard Deviation
Inferential Statistics: Testing Hypothesis
Formulating Hypotheses

• A research hypothesis is a stated relationship between two or more variables (independent variables (x) and dependent variables (y))
• A null hypothesis is a stated non-relationship between two or more variables
• Hypotheses must be falsifiable
• Hypotheses stating causal relationships should indicate direction of causality or relationships
Procedures for Testing

- State the null and alternative hypotheses
- Set the significance level before the research study
- Most researchers use .05 as the significance level
  - Note that the significance level is also called the alpha level or, more simply, alpha)
- Collect appropriate data and determine the calculated value of the Test Statistic (e.g. $Z_{\text{calc}}$, $t_{\text{calc}}$, $\chi^2_{\text{calc}}$, $F_{\text{calc}}$, etc.)
- Obtain the probability value (p-value)
- Compare the p-value to the significance level
- Make the statistical decision
Scenario 1

• If: Probability value ≤ significance level (i.e., probability value ≤ alpha)
  • Then: Reject the null hypothesis.
  • And: Conclude that the research finding is statistically significant

• In practice, this usually means:
  • If: Probability value ≤ .05
  • Then: Reject the null hypothesis.
  • And: Conclude that the finding is statistically significant

Scenario 2

• If: Probability value > significance level (i.e., probability value > alpha)
  • Then: Fail to reject the null hypothesis.
  • And: Conclude that the research finding is not statistically significant

• In practice this usually means:
  • If: Probability value > .05
  • Then: Fail to reject the null hypothesis
  • And: Conclude that the research finding is not statistically significant.
### Example of a Decision Table

<table>
<thead>
<tr>
<th>P value</th>
<th>Wording</th>
<th>Summary</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.05</td>
<td>Not significant</td>
<td>ns</td>
<td>Accept H₀</td>
</tr>
<tr>
<td>0.01 to 0.05</td>
<td>Significant</td>
<td>*</td>
<td>Reject H₀</td>
</tr>
<tr>
<td>0.001 to 0.01</td>
<td>Very significant</td>
<td>**</td>
<td>Reject H₀</td>
</tr>
<tr>
<td>&lt; 0.001</td>
<td>Extremely significant</td>
<td>***</td>
<td>Reject H₀</td>
</tr>
</tbody>
</table>
Scheme for Choosing a Statistical Test

Are You Examining Relationships Between Variables or Examining the Differences Between Groups/Conditions?

**Relationships Between Variables**
- How Many Variables?
  - Two Variables
    - Pearson Correlation (PR) Coefficient
    - Spearman test/Chi Square (NPR) Ordinal
    - Two Way Contingency Tables (NPR)(Nominal)
  - More than Two Variables
    - Regression Factor Analysis
    - Loglinear Analysis of Multi-way Contingency Tables (Nominal Data)

**Differences Between Groups/Conditions**
- How Many Groups?
  - Two Groups
    - Independent Different (DS) Related (SS)?
      - Independent
        - t-test for IS
      - Related
        - t-test for PS
        - Mann-Whitney U Test (NPR)/Ordinal
        - Wilcoxon test (NPR)/Ordinal
        - Chi Square Nominal (NPR)
        - McNemar test Nominal (NPR)
  - More than Two groups
    - ANOVA
    - What Design?
      - BS
      - WS
        - One-Way ANOVA (PR)
        - Friedman test (NPR)/Ordinal
        - Chi-Square (NPR)/Nominal
        - Cochrans Q test (NPR)/Nominal

Abbreviations
- BS=Between Subjects
- WS=Within Subjects
- DS=Different Subjects
- SS=Same Subjects
- PR=Parametric
- NPR=Non-Parametric
- IS=Independent Samples
- PS=Paired Samples
Analytical Phase: Discussion of Findings

• Discussion relating to research objectives
• Discussion relating to research questions
• Discussion relating to literature
Analytical Phase: Conclusion

• Research conclusion is often the most difficult part to write
• Conclusion is what a reader remembers best
• Elements of conclusion
  – Synthesis not summary of the study
  – Answering the research question or achieving the goal
  – Providing the reader with the big picture and the details of findings or vice versa
  – Stating the importance/significance/contribution of a study
Preparing the Formal Report Checklist

- Why was the study conducted?
- What research questions and hypotheses were evaluated?
- How questions were turned into a research design?
- What conclusions were drawn—does results support or contradict existing theories?
- What differences were observed between the hypotheses and the results?
Thanks!
Questions or comments?

Ben Daniel, PhD
Higher Education Development Centre (HEDC)
University of Otago
Dunedin, NEW ZEALAND
ben.daniel@otago.ac.nz