Introduction to Research

Methodology of Statistical Research. Statistical Method and Logic of Statistical Inference.

Tomáš Oleš
Department of Economic Policy
Faculty of Economics and Finance

January 29, 2025

Course Description

Course Objectives:

- Focus on practical application of empirical research in economics with an emphasis on public policy questions.
- Begin with randomized experiments and progress to basic regression analysis, introducing statistical software STATA.
- Emphasis on working with real datasets, replicating results from scientific studies, and mastering practical steps in data description and analysis.
- Familiarize students with key econometric concepts and methods necessary for understanding contemporary empirical research and conducting their own projects.
- Cover regression analysis principles and modern econometric techniques aimed at identifying causal relationships.

Learning Outcomes: Applied Data Analysis for Public Policy

- Master modern methods of data analysis, visualization, hypothesis testing, and basics of linear regression.
- Gain proficiency in using STATA for data processing and analysis, applicable in personal research projects.
- Understand basic econometric concepts, estimation methods, and statistical hypothesis testing techniques.
- Differentiate between correlation and causation and learn experimental and quasi-experimental designs (e.g., RCT, Difference-in-Differences, instrumental variables, etc.).
- Critically evaluate scientific studies and analyses, apply data insights in public policy contexts, and argue effectively.

"We are what we repeatedly do. Excellence, then, is not an act, but a habit."
– Aristotle

Course Completion Requirements

Grading Breakdown:

- **20%** – Participation in seminars
- **50%** – Assignments
- **30%** – Final exam

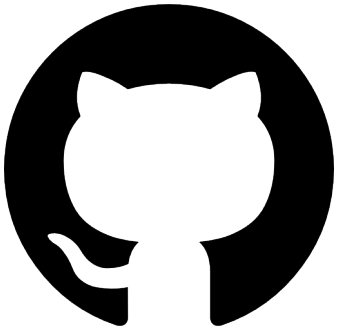
Successful completion of the course requires consistent work throughout the semester and passing the final evaluation.

Required Literature

- Mehmetoglu, M., & Jakobsen, T. G. (2022). *Applied Statistics Using STATA: A Guide for the Social Sciences.*
- Lukáš Laffers (2024). *Pravdepodobnosť a štatistika 1:* Open Access e-text: `https://lukaslaffers.github.io/pas1/`
- Lukáš Laffers (2021). *Moderná aplikovaná regresia 1:* Open Access e-text: `https://static1.squarespace.com/static/52e69d46e4b05a145935f24d/t/64a0a2214abdb23994e932a2/1688248868079/MAR1_poznamkyMain.pdf`
- IFP (2016). *Ideálny čas pre adresnejšie zdanenie fajčiarov:* Open Access e-text: `https://www.mfsr.sk/files/archiv/priloha-stranky/19972/81/Idealny-cas-adresnejsie-zdanenie-fajciarov.pdf`
- IFP (2019). *V nájme ďalej zájdeš: Podpora bývania na Slovensku:* Open Access e-text: `https://www.mfsr.sk/files/archiv/24/Podpora_byvania_analyza.pdf`
- CORE Team (2018). *Doing Economics.* Open Access e-text: `https://core-econ.org/doing-economics`
- Cunningham, S. (2021). *Causal Inference: The Mixtape.* Yale University Press. (Chapters 4 and 5)

Where Does ADAPP Live?

GitHub Repository: The central hub for all course materials, datasets, and code.



`https://github.com/tomasoles/applied_data_analysis_for_public_policy/tree/main`

Agenda

- Understand the methodological foundations of statistical research.
- Grasp the logic behind different types of statistical inference.
- Recognize the importance of sound theoretical frameworks.
- Gain insights into writing quantitative research papers and presenting data effectively.

The Goal of Scientific Research and Statistics

- **Scientific Research:**
  "The goal of scientific research is to make conclusions that go beyond the collected data." (King et al., 1994: 8)
- **Large-N Studies:**
  - Enable generalizations about causal effects, provided causality is established.
  - Depend on the availability of data (sample or full population).
- **Types of Statistics:**
  - Descriptive: Describes distributions.
  - Inferential: Examines relationships, enables predictions, and hypothesis testing.
- **Inferential Statistics:**
  - Tool of the positivist tradition.
  - Identifies patterns and regularities in the observable world.
  - Roots in the systematic collection of data for induction (e.g., John Graunt, Sir William Petty, Hermann Conring).

The History of Statistical Methods in Social Sciences

- **Key Contributions to Modern Statistics:**
  - **Francis Galton:** Introduced the correlation coefficient, scatter plot, and regression analysis.
  - **Karl Pearson:** Continued Galton's work and developed statistical methods further.
  - **Émile Durkheim:** Placed statistics at the center of social sciences, linking variables such as suicide and religion.
- **Before Statistics in Social Sciences:**
  - Research relied on philosophical reasoning and experiential facts (Ellwood, 1931).
  - Example: An event in 17th-century Norway involving Scottish mercenaries illustrates this pre-statistical approach. In 1612, over 300 Scottish mercenaries crossed Norway to join Swedish forces during the Kalmar War. They encountered a lone Norwegian farmer in Gudbrandsdalen, leading to a dramatic event (story continues...)

Statistical Evidence vs. Common Sense

- **The Sinclair Anecdote:**
  - Captain George Sinclair concluded, without numerical evidence, that a frightened peasant was hiding in a linden tree.
  - Modern social science would demand further evidence, such as 95% certainty, before trusting this conclusion.
  - Quantitative researchers would rely on statistical tests, not just experience or common sense.
- **Outcome of the Incident:**
  - Sinclair's intuition was correct, but the situation ended tragically:
    - About 500 Norwegian farmers ambushed the Scottish mercenaries.
    - George Sinclair was killed, and the surviving Scotsmen faced a grim fate.
- **Key Lesson:**
  - The social sciences increasingly rely on data, statistical tests, and evidence rather than intuition alone.
  - This reflects the shift from common sense to a data-driven approach in understanding phenomena.

The Logic Behind Statistical Inference

- **Generalization in Social Science:**
  - Statistical methods allow generalizations about the empirical world.
  - Properly defining the population and sample is essential.
- **Common Errors to Consider:**
  - Sampling error, interviewer variability, non-response, and questionnaire problems (Groves, 1989).
  - Context and assumptions underlying statistical models must be considered (John, 2002).
- **Impact of Sample Size:**
  - Sample size greatly influences the ability to generalize.
  - Raises questions:
    - "Does population size matter for significance?"
    - "What if we examine the whole population?"

The Logic Behind Statistical Inference

- **Generalization in Social Science:**
  - Statistical methods allow generalizations about the empirical world.
  - Properly defining the population and sample is essential.
- **Common Errors to Consider:**
  - Sampling error, interviewer variability, non-response, and questionnaire problems (Groves, 1989).
  - Context and assumptions underlying statistical models must be considered (John, 2002).
- **Impact of Sample Size:**
  - Sample size greatly influences the ability to generalize.
  - Raises questions:
    - "Does population size matter for significance?"
    - "What if we examine the whole population?"

Probability Theory in Inferential Statistics

- **Central Limit Theorem:**
  - As sample size N increases, the sampling distribution of the mean becomes approximately normal.
  - The sampling distribution will fall around the variable's population mean.
- **Sampling Assumptions:**
  - Units must be sampled randomly or with a known probability of selection.
  - Stratified sampling divides the population into districts to closely examine subgroups.
- **Sample Size:**
  - Large samples ($N = 1000-1200$) make it easier to obtain significant results compared to small samples ($N = 25$).

Causation, P-Values, and Regression

- **P-Values:**
  - Denote the probability of being mistaken when rejecting the null hypothesis.
  - The closer the p-value is to 0, the more certain we can be about the hypothesis.
- **Correlation vs. Causation:**
  - Correlations observed in regression analysis do not imply causation.
  - Observed relationships must be interpreted using theories about human action (Elster, 1989).
- **Experimental Method:**
  - Provides the best means to assess causal relationships by manipulating environments.
  - Ensures that discovered relationships are not influenced by context (Moses and Knutsen, 2012). We will talk about this at the end of the course :).

Population Size and Required Sample Size

- The size of the **sample** matters for making inferences, not the population size.
- A sample of **1000** is equally effective for small and large populations.
- The **exception**: If the sample exceeds a few percent of the total population, confidence intervals shrink.

Population	Sample
10	10
50	44
100	80
200	132
500	217
1000	278
3000	341
100,000+	385

Table: Sample size needed for a 95% confidence interval

Why Use Significance Levels When Examining the Whole Population?

- **Investigating the Whole Population:**
  - Social scientists may analyze an entire population (e.g., all fast food restaurants in a city).
  - Unlike sample theory, this follows **stochastic model theory**, which generalizes from observed data to the underlying process.
- **Stochastic vs. Sample Theory:**
  - Sample theory generalizes from a sample to a population.
  - Stochastic models recognize that results vary due to randomness, even under constant conditions.
- **Why Significance Levels Matter:**
  - Even when studying a whole population, observed relationships may result from random processes.
  - Confidence intervals and significance levels help distinguish real associations from random chance.
  - A lack of statistical significance suggests the observed association is as likely due to chance as to an actual relationship (Gold, 1969; Henkel, 1976).

What is Science? ... and Scientific Claim?

General Laws and Theories

- **Challenges in Establishing Causal Inference:**
  - Hume: No finite amount of experimentation can prove that X causes Y.
  - Popper: A proposition is scientific only if it is **falsifiable**.
  - Social scientists should aim for conclusions that align with both theory and common sense Mayo (1980).
- **The Role of Theories:**
  - Theories explain social behavior and must:
    - Define constructs.
    - Describe causal relationships.
    - Apply across different settings and times (Smith and Mackie, 2000).
- **Statistical Laws vs. Universal Laws:**
  - Hempel (1959):
    - Statistical laws provide probabilistic explanations.
    - Universal laws predict a specific outcome whenever conditions are met.
- **Limitations of Statistical Research:**
  - Patterns exist in nature but measurement errors affect accuracy.
  - Proxies in surveys may not perfectly capture what we measure.
  - Strong theoretical reasoning must support statistical findings.

Writing a Quantitative Research Paper

- **Importance of Quantitative Research:**
  - A large portion of social science research is quantitative.
  - Statistical skills improve your chances of publishing in academic journals.
- **Key Components:**
  - **Problem Statement:** Formulate a research question or testable hypothesis.
  - **Research Methods:** Describe your sample, population, and variables.
  - **Descriptive Statistics:** Include N, mean, standard deviation, skewness, and kurtosis.
  - **Results Section:** Present regression tables and summarize findings.

Table: Regression Model of Welfare Attitudes

Variable	β	**Std. E**	**p-value**
Constant	4.664	0.195	0.000
Eastern European	0.391	0.292	0.203
Asian	0.631	0.364	0.107
R^2	0.376		
N	19		

Questions

1. What is the main advantage of large-N studies compared to small-N studies?
2. In what way does population size matter when it comes to statistical inference?
3. What is the purpose of a sensitivity analysis?

References I

Elster, J. (1989). *Nuts and Bolts for the Social Sciences*. Cambridge University Press, Cambridge.

Gold, D. (1969). Statistical tests and substantive significance. *American Sociologist*, 4(1):42–46.

Groves, R. (1989). *Survey Errors and Survey Costs*. Wiley, New York.

Hempel, C. (1959). The logic of functional analysis. In Gross, L., editor, *Symposium on Sociological Theory*, pages 271–307. Harper & Row, New York.

Henkel, R. (1976). *Tests of Significance*. Sage, Beverly Hills, CA.

John, P. (2002). Quantitative methods. In Marsh, D. and Stoker, G., editors, *Theory and Methods in Political Science*. Palgrave, New York, 2 edition.

Mayo, D. (1980). The philosophical relevance of statistics. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, 1980(1):97–109.

Moses, J. and Knutsen, T. (2012). *Ways of Knowing: Competing Methodologies in Social and Political Research*. Palgrave, Basingstoke, 2 edition.

Smith, E. and Mackie, D. (2000). *Social Psychology*. Psychology Press, Philadelphia, 2 edition.