SUMAPS 5193: Statistics for Sustainability Management
Instructors: Bruce M. Kahn, Ph.D.

Course Overview

The course introduces practitioners sustainability management to the data analysis techniques and statistical methods which are indispensable to their work. The class teaches how to build statistical substantiation and to critically evaluate it in the context of sustainability problems. The statistics topics and examples have been chosen for their special relevance to sustainability problems, including applications in environmental monitoring, impact assessment, and econometric analyses of sustainable development. Students are assumed to have had no previous exposure to statistics.

Course Objectives

This course demonstrates how to conduct a quantitative analysis of an organization’s work processes and operations, resource utilization, and environmental impact necessary to create a rationale for implementing sustainability initiatives. Statistical topics, including probability and random variables, will be discussed in both theory and in their practical applications for sustainability managers. This course will provide students with the skills to conduct regression analysis, to conduct hypothesis and estimation testing, to design surveys, and to prepare statistics packages. These quantitative skills are necessary for a professional manager responsible for the management of people, finances and operations toward sustainability goals.

Course Content

Session 1 Introduction

Readings: Leekley, Chapter 1 and Chapter 2.

Session 2 Describing Data: Tables and Graphs
Measures of Central Tendency: Mean, Median, Mode, Advantages and Disadvantages; Measures of Dispersion: Mean Absolute Deviation, Variance and Standard Deviation, Quantiles and Inter-Quartile Range; Skewness and Kurtosis; Plots: Histogram, Q-Q, ECDF, Box, Scatterplot, Smoothers

Readings: Leekley, Chapter 2
Corporate Ecosystems Review (WRI)

Session 3 Describing Data: Summary Statistics
Measures of Central Tendency: Mean, Median, Mode, Advantages and Disadvantages; Measures of Dispersion: Mean Absolute Deviation, Variance and Standard Deviation, Quantiles and Inter-Quartile Range; Skewness and Kurtosis; Plots: Histogram, Q-Q, ECDF, Box, Scatterplot, Smoothers

Readings: Leekley, Chapters 3,

**Homework 1:** Exercises from Leekley Chapters 2

Assessing social responsibility: A quantitative analysis of Appraisal in BP's and IKEA's social reports
http://dcm.sagepub.com/content/6/1/55.full.pdf+html

Corporate Management, Industry Competition and the Sustainability of Firm Abnormal Profitability
http://link.springer.com/content/pdf/10.1023%2FA%3A1022489324208

**Session 4 Basic Probability**
The Origins of Probability Theory; Events; The Laws of Probability; Probability of A or B; Conditional Probability; Joint Probability; Bayes' Rule; Permutations and Combinations, Discrete vs. Continuous, Category vs. Ordered vs. Quantitative; Expected Value, Variance; Discrete Random Variables: Binomial, Poisson, Hypergeometrics; Continuous Random Variables: Normal, Chi-Squared, Exponential

Readings: Leekley, Chapter 4,

Lennox and King. Does it pay to be green? 2010.

**Homework 2:** Exercises from Leekley Chapters 3.

**Session 5 Probability Distributions**
The Origins of Probability Theory; Events; The Laws of Probability; Probability of A or B; Conditional Probability; Joint Probability; Bayes' Rule; Permutations and Combinations, Discrete vs. Continuous, Category vs. Ordered vs. Quantitative; Expected Value, Variance; Discrete Random Variables: Binomial, Poisson, Hypergeometrics; Continuous Random Variables: Normal, Chi-Squared, Exponential

Readings: Leekley, Chapter 5,

Deriving sustainability measures using statistical data: A case study from the Eisenwurzen, Austria.

Life Cycle Tools within Ford of Europe's Product Sustainability Index
Session 6 Sampling and Sampling Distributions
Random sampling, stratified sampling, cluster sampling, the t-table, Environmental Sampling, Surveys and experiments; Experimental design; Constructing Samples; Constructing indices and scales; Examples of bad survey questions; Replication in natural vs social sciences.

Readings: Leekley, Chapter 6,
Chapter 12 of The Signal and the noise, Nate Silver.

Homework 4: Exercises from Leekley Chapter 5

Session 7 Estimation and Confidence Intervals
Point and interval estimators, estimate of proportion, populations mean

Readings: Leekley Chapter 7.
Dimson et al, 2012
Evans and Peiris, 2010

Homework 5: Exercises from Leekley Chapter 6

Session 8 Hypothesis Testing
Independence of Observations Central Limit Theorem Sampling Distributions Tests for distribution (Kolmogorov-Smirnov, Q-Q tests). The one-sample t-test for a population mean; One-sample Chi-squared test for population variance; Two-sample t and z tests for population mean; two-sample z test for population variance

Readings: Leekley, Chapter 8,
Homework 6: Exercises from Leekley Chapter 7

Midterm Due: Distributed on Feb 28. Review Eccles paper and develop research proposal
Session 9 Hypothesis Testing
Independence of Observations Central Limit Theorem Sampling Distributions Tests for distribution (Kolmogorov-Smirnov, Q-Q tests). The one-sample t-test for a population mean; One-sample Chi-squared test for population variance; Two-sample t and z tests for population mean; two-sample z test for population variance

Readings: Leekley, Chapter 9
Guenster et al., 2006
Lev et al., 2008

Homework 7: Exercises from Leekley Chapter 8

Session 10 Hypothesis Testing
Independence of Observations Central Limit Theorem Sampling Distributions Tests for distribution (Kolmogorov-Smirnov, Q-Q tests). The one-sample t-test for a population mean; One-sample Chi-squared test for population variance; Two-sample t and z tests for population mean; two-sample z test for population variance

Readings: Leekley, Chapter 10
Groysberg et al., 2008
Crook et al. 2011.

Homework 8: Exercises from Leekley Chapter 9

Session 11 Hypothesis Testing
Independence of Observations Central Limit Theorem Sampling Distributions Tests for distribution (Kolmogorov-Smirnov, Q-Q tests). The one-sample t-test for a population mean; One-sample Chi-squared test for population variance; Two-sample t and z tests for population mean; two-sample z test for population variance

Readings: Leekley, Chapter 11
Edmans, A., 2011.
Harjoto and Jo, 2011

Homework 9: Exercises from Leekley Chapter 10

Session 12 Regression Analysis
Covariance and Correlation, Spearman Rank Correlation, Correlation Tests; Scatterplot and Univariate Regression. Regression Error, Coefficient of Determination; Assumptions of the Linear Regression Model; Multivariate regression, Hypothesis Tests about Coefficients and the Model; Specification; Missing Data; Heteroskedasticity; Discrete Dependent Variables

Readings: Leekley, Chapters 12
Semenova and Hassel, 2008.
Session 13 Regression Analysis
Covariance and Correlation, Spearman Rank Correlation, Correlation Tests; Scatterplot and Univariate Regression. Regression Error, Coefficient of Determination; Assumptions of the Linear Regression Model; Multivariate regression, Hypothesis Tests about Coefficients and the Model; Specification; Missing Data; Heteroscedasticity; Discrete Dependent Variables

Readings: Leekley, Chapters 13

Session 14 Time-Series Analysis
Exploiting patterns over time, basic components of a time series, seasonal variation, the long-term trends, the business cycles, forecasting.

Readings: Leekley Chapter 14

Session 15 Environmental Applications of Statistics

Readings:

Session 16: Final Exam Presentations
Method of Instruction and Evaluation

The course is based on 200 points.

Homework Assignments: There will be 13 weekly problem-solving assignments each worth 10 points for a total of 130 points.

Participation: Each student will make a presentation on the week’s reading “sustainability” reading assignments plus their active participation in class worth 10 points.

Tests: There will be a take-home midterm exam and a take-home final, each worth 30 points.

The Midterm is due on March 19th.
The Final Exam is due on May 7th.

I will hold office hours on Tues’s from 6:30-7:45 pm at 2929 Broadway, by appointment. Recitation Periods TBD

Text Books

All additional readings will be listed in Courseworks. Any readings whose full-text is not available through the links in Courseworks will be placed on reserve at the Library.

Additional Books of Interest on Reserve:

- The Black Swan: The Impact of the Highly Improbable, Nassim Nicholas Taleb
- Moneyball: The Art of Winning an Unfair Game, Michael Lewis
- Freakonomics: A Rogue Economist Explores the Hidden Side of Everything, Steven Levitt and Stephen J. Dubner.
- How to Lie with Statistics, Darrell Huff
- The Signal and the Noise: Why So Many Predictions Fail — but Some Don’t, Nate Silver
- Capitalism at a Crossroads, Stuart Hart

Policies

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The School of Continuing Education does not tolerate cheating and/or plagiarism in any form. Those students who violate the Code of Academic and Professional Conduct will be subject to the Dean’s Disciplinary Procedures. The Code of Academic and Professional Conduct can be viewed online:
Please familiarize yourself with the proper methods of citation and attribution. The School provides some useful resources online; we strongly encourage you to familiarize yourself with these various styles before conducting your research:

http://library.columbia.edu/help/howto/endnote.html

Violations of the Code of Academic and Professional Conduct will be reported to the Associate Dean for Student Affairs.

Accessibility Statement

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http://health.columbia.edu/services/ods/support