SUMA K4193: 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

General Research Methodology: Inductive Method, Hypothetico-Deductive Method, Experimental and Non-Experimental Design, Causal Inference; The Uses of Statistics in Sustainability Studies: Impact Assessment, Monitoring, Auditing, Polling; Using Statistics in Research: Sample vs. Population, Description vs. Inference, Sampling Error and Bias

Readings: Leekley, Chapter 1, Manly, Chapter 1, Eccles et al. 2012., Corporate Ecosystems Review, World Resources Institute.

Session 2 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, Chapter 2, Dimson et al, 2012, Evans and Peiris, 2010

Session 3 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, Guenster et al., 2006, Lev et al., 2008
Homework 1: Exercises from Leekley Chapters 2

Session 4 Probability and 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 4, Manly Chapter 3, Groysberg et al., 2008, Crook et al. 2011.
Homework 2: Exercises from Leekley Chapters 3.

Session 5 Probability and 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, Manly Chapter 3, Edmans, A., 2011. Harjoto and Jo, 2011
Homework 3: Exercises from Leekley Chapter 4

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, Manly Chapter 2, Chapter 4, Semenova and Hassel, 2008.
Homework 4: Exercises from Leekley Chapter 5

Session 7 Estimation and Confidence Intervals

Point and interval estimators, estimate of proportion, populations mean
Leekly Chapter 7, Manly Chapter 4. Olsson, 2007.
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, Allouche and Larouche 2005, Amman et al. 2010.
Homework 6: Exercises from Leekley Chapter 7

Midterm Due Covering Session 1-7

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, Manly Chapter 5, Garz et al. 2002
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, Manly Chapter 6,

Life Cycle Tools within Ford of Europe's Product Sustainability Index
http://link.springer.com/content/pdf/10.1065%2Flca2006.08.267

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, Manly Chapter 7
Deriving sustainability measures using statistical data: A case study from the Eisenwurzen, Austria.
http://www.sciencedirect.com/science/article/pii/S1470160X09001411

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; Heteroschedasticity; Discrete Dependent Variables

Readings: Leekley, Chapters 12, Manly Chapter10
Modelling More Sustainable Aluminium
http://www.alcoa.com/sustainability/en/pdfs/KMartchek_IJLCA_7772.pdf
Homework 10: Exercises from Leekley Chapter 11

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Readings: Leekley, Chapters 13, Manly Chapter 11
Corporate Management, Industry Competition and the Sustainability of Firm Abnormal Profitability
http://link.springer.com/content/pdf/10.1023%2FA%3A1022489324208

Homework 11: Exercises from Leekley Chapter 12

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, Manly Chapter 8,
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

Homework 12: Exercises from Leekley Chapter 13

Session 15 Environmental Applications of Statistics

Environmental Valuation: Hedonic Pricing Models, Stated Willingness to Pay, Travel Cost Models, Random Utility Models; Environmental monitoring: Designs, CUSUM Charts, Chi-squared Tests; Spatial data: Quadrat Counts, Tests for non-uniformity, Spatial Autocorrelation and Variograms,, Kriging.

Readings: Manly, 9;
Homework 13: Exercises from Leekley Chapter 14
Homework: Final Exam Due Covering Sessions 8-14

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 at total of 130 points or 65% of the course grade.

Tests: There will be a take-home midterm exam and a take-home final, each worth 35 points or 17.5% of the grade each.

Textbooks and Reading

Robert M. Leekley, Applied Statistics for Business and Economics, CRC Press, 2009, ISBN #978-1-4398-0568-8

Bryan F. J. Manly, Statistics for Environmental Science and Management, Second Edition, CRC Press, 2009, ISBN #978-1-4200-6147-5

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

Academic Integrity

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:

http://ce.columbia.edu/node/217

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.

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