SUMA PS5193: Statistics for Sustainability Management
Instructor: Bruce M. Kahn, Ph.D.
Spring 2024

Course Overview

The course introduces practitioners of 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 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

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,

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

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.

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: Leekly Chapter 6.

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

Readings: Leekley, Chapter 7,

Midterm Due: Distributed on March 6th and due on March 20th.
Review Eccles paper and develop research proposal

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

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

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

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, Chapters 11

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

Session 13: Climate Change and Statistics
Readings: Chapter 12 of The Signal and the noise, Nate Silver.

Session 14 Multiple 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 Chapter 13

Session 15: 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 16: Final Exam Presentations
The Final Exam is due on May 8th.

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.

Participation: Each student will make a presentation on the weeks 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 20th.
The Final Exam is due on May 8th.

I will hold office hours on Thursday's from 4:30-5:45 pm at 2929 Broadway, by appointment. Recitation Periods TBD

Text Books

- Robert M. Leekley, Applied Statistics for Business and Economics, CRC Press, 2009,

- Applied statistics in business and economics. Doane and Seward

- Naked statistics : stripping the dread from the data. Charles Wheelan.

- Data science applied to sustainability analysis. Dunn and Balaprakash https://www-sciencedirect-com.ezproxy.cul.columbia.edu/book/9780128179765/data-science-applied-to-sustainability-analysis

- The nature of data : infrastructures, environments, politics. Goldstein and Nost https://ebookcentral.proquest.com/lib/columbia/detail.action?docID=7054866

Readings/Research Articles

The following 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.

Fuoli, M. (2012). Assessing social responsibility: A quantitative analysis of Appraisal in BP's and IKEA's social reports. Discourse & Communication, 6(1), 55-81. https://doi.org/10.1177/1750481311427788

Samer Abdallah samer.abdallah@elec.qmul.ac.uk & Mark Plumbley (2009) Information dynamics: patterns of expectation and surprise in the perception of music, Connection Science, 21:2-3, 89-117, DOI: 10.1080/09540090902733756

Liang, Y., Lee, S.A. Fear of Autonomous Robots and Artificial Intelligence: Evidence from National Representative Data with Probability Sampling. Int J of Soc Robotics 9, 379–384 (2017). https://doi.org/10.1007/s12369-017-0401-3

Khosravi, Faramarz, Gokhan Izbirak, and Seyed Mahdi Shavarani. "Application of bootstrap re-sampling method in statistical measurement of sustainability." Socio-Economic Planning Sciences 75 (2021): 100781.

Nate Silver: A Climate of Healthy Skepticism. From The Signal and the Noise: Why So Many Predictions Fail — but Some Don't , Nate Silver

Carvalho, Marly M., and Roque Rabechini Jr. "Can project sustainability management impact project success? An empirical study applying a contingent approach." International Journal of Project Management 35.6 (2017): 1120-1132.

Zorio, Ana, Maria A. García‐Benau, and Laura Sierra. "Sustainability development and the quality of assurance reports: Empirical evidence." Business strategy and the environment 22.7 (2013): 484-500.

Crook, T. Russell, et al. "Does human capital matter? A meta-analysis of the relationship between human capital and firm performance." Journal of applied psychology 96.3 (2011): 443.

Olsson, Rickard, (2007), Portfolio performance and environmental risk, No 2007/4, Sustainable Investment and Corporate Governance Working Papers, Sustainable Investment Research Platform, https://EconPapers.repec.org/RePEc:hhb:sicgwp:2007_004.

Semenova, Natalia, and Lars G. Hassel. "Financial outcomes of environmental risk and opportunity for US companies." Sustainable Development 16.3 (2008): 195-212.

Brotcke, L. Time to Assess Bias in Machine Learning Models for Credit Decisions. J. Risk Financial Manag. 2022, 15, 165. https://doi.org/10.3390/jrfm15040165

Nieto-Rodriguez and Vargas. 2023. The Opportunities at the Intersection of AI, Sustainability, and Project Management. Harvard Business Review:2023

Lanza, A, Bernardini, E. and Faiella, E. Mind the gap! Machine learning, ESG metrics and sustainable investment. Banca Italia Occasional Papers. June 2020.

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 .

Course Policies

Attendance
Students are expected to arrive on time, attend all classes, and to stay until the end of class unless they have notified the instructor at the beginning of the session that they will be leaving early. Each unexcused absence will result in a 1 point deduction from the participation grade.

Late Assignment Policy
Assignments are due on the dates/times identified. One letter grade will be deducted from any assignment submitted after the due date/time. No assignment will be accepted after the deadline for submitting final grades.

Incompletes
As outlined in the School's grading and academic starts policy, "A grade of 'I' (incomplete) is a temporary grade indicating failure to complete assigned work. The mark is given only upon the request of the student and at the discretion of the instructor. The student and faculty member must sign a completed 'Request for Grade of

Incomplete Form' before the final class session. The 'I' must be removed within one year after the end of the semester in which the student received the grade. Students seeking an extension of this time limit must have the approval of the instruction and successfully petition of the director of their program. If no petition is made, of if the petition is unsuccessful, the grade is chanced to an N-Permanent Incomplete- which remains on the student's permanent record.

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.

Accessibility Statement

Columbia is committed to providing equal access to qualified students with documented disabilities. A student's disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website:
http://health.columbia.edu/services/ods/support

APPENDIX A
School Policies

Copyright Policy

Please note -- Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction.

One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

Academic Integrity

Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times.

SCE holds each member of its community responsible for understanding and abiding by the SCE Academic Integrity and Community Standards posted at http://ce.columbia.edu/node/217 . You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Accessibility

Columbia is committed to providing equal access to qualified students with documented disabilities. A student’s disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this

service, please visit the University's Health Services website: http://health.columbia.edu/services/ods/support.

Accessibility Statement – I want you to succeed in this course. Contact disability@columbia.edu for learning accommodations.

Names/Pronouns – You deserve to be addressed in a manner that reflects your identity. You are welcome to tell me your pronoun(s)and/or name (if different from University records) at any time, either in person or via email.

Discrimination – We embrace the diversity of gender, gender identity & expression, sex, sexual orientation, race, ethnicity, national origin, age, religion, disability status, family status, socioeconomic background, and other visible and non-visible identities. Columbia University does not tolerate unlawful discrimination, discriminatory harassment, sexual assault, domestic violence, dating violence, stalking, or sexual exploitation and all such conduct is forbidden by Columbia University Policy.

Duty to Report – You deserve a University community free from discrimination, harassment, and gender-based misconduct including sexual harassment, sexual assault, domestic and dating violence, stalking, and sexual exploitation. It is therefore University policy to require Columbia faculty and staff to report to EOAA any instance or allegation of prohibited conduct involving any undergraduate or any graduate student that is disclosed to, observed by, or otherwise known to that employee. This requirement to report is in place to help ensure that students are provided appropriate resources and to allow the University to mitigate harm to our community.

Confidential Resources - There are confidential resources on campus who do not have a Duty to Report, including:

- Sexual Violence Response & Rape Crisis/Anti-Violence Support Center (SVR)
- Ombuds Office
- Medical Services
- University Counseling and Psychological Services
- University Pastoral Counseling
- Columbia Office of Disability Services

University employees working in a confidential capacity will not report information shared with them.

Inclusion - In the M.S. in Sustainability Management program, faculty and staff are committed to the creation and maintenance of "inclusive learning" spaces – classrooms and other places of learning where you will be treated with respect and dignity, and where all individuals are provided equitable opportunity to participate, contribute, and succeed.

In our Sustainability Management K4100 classroom , all students are welcome regardless of race/ethnicity, gender identities, gender expressions, sexual orientation, socio-economic status, age, disabilities, religion, regional background, Veteran status, citizenship status, nationality and other diverse identities that we each bring to class.