11.220/Quantitative Reasoning and Statistical Methods for Planning
Syllabus and Orientation Notes

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1 Contact Information

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1.1 Stellar Site

The Stellar site for the class is at: [https://stellar.mit.edu/S/course/11/sp18/11.220/](https://stellar.mit.edu/S/course/11/sp18/11.220/) Please look there for all assignments and readings (other than the “required books” described in section 4.1.1 on page 5).

2 Overview and Prefatory Remarks

Planners use numbers, and planners use reasoning

A defensive footnote may be in order: Yes, this means all of us — designers, policy-wonks, real-estate developers, bureaucrats, community activists, politicians, diplomats, bankers, traffic-modelers, anarcho-eco-communists — all of us. You wouldn’t be here if you didn’t appreciate the value of these skills, whether to develop your own quantitative arguments, question the validity of the arguments and analyses of others, or simply to understand the quantitative aspects of the complexity in the world around us.
and creative in your application of the skills you will learn in quantitative reasoning, statistical methods, and the presentation and visualization of complex information, but also to be critical of these methods where appropriate questioning whether the the Modern Age’s confidence in statistics — the prevailing faith in “hard numbers,” “scientific accuracy,” and “dispassionate logic” — may at times be overstated or unjustified.

2.1 A few thoughts on quantitative and qualitative methods

Much is made of the distinction between quantitative and qualitative approaches. Fortunately, planning is a field where you will be able (and expected) to master both, so we don’t need to waste a lot of space here with rhetorical debates about which is “truer,” or better, or more persuasive. But for the time being, for this class, we need to concentrate on the quantitative aspects of the field (hence the “Q” in this particular “QR”); we will be concerned with things that can be measured, compared, and analyzed with regard to scale, size, variation, frequency and distribution, degree, and proportion. We will also be concentrating on the differences between observed samples and entire populations, and using statistical tools to distinguish between meaningful differences and random noise.

That said, it may be worth meditating on the possibility that from an existential perspective, things in the world are not really either quantitative or qualitative — these words refer to ways we approach these things (or events, phenomena, ideas — whatever). To use a hackneyed old example, consider a tree in the forest: it is neither quantitative nor qualitative — it is just there, being tree-ey. These aspects of the tree only come out in relation (or perhaps in reaction) to our observation and discussion of it: “how tall is it?” “how old?” “is it healthy?” “is it pretty?” “what’s it good for?” Depending on how we want to answer these questions, we may chose more quantitative or more qualitative methods. Interestingly, which approach will be more helpful for which questions is not always obvious.

Most of the implications of this line of thinking are far beyond our purposes here, but it does help to point to the artificiality of the distinction, and may help us see the these two types of approaches more as a continuum and less as two irreconcilable world views.

2.2 Remember the “R” in “QR”

The second half of “QR” stands for “Reasoning.” As you begin to prepare your mind for the course, please remember that this is not just a statistics course. The quantitative part — dealing with gathering, analysis, and presentation of numbers — is certainly a key aspect of the class. But equally important will be developing skills in reasoning: making and critiquing arguments; stating and investigating hypotheses; avoiding bias in your own work and identifying it in

\[\text{Page 2}\]
the work of others; struggling over the vagaries of cause and effect; learning how to simplify complexity without doing violence to truth; and a host of other challenges that have more to do with logic and clear-thinking than with numbers and data per se.

2.3 A note about knowledge and belief

In the first few weeks of the class, we will touch on the difference between knowledge and belief: a belief may be true, but only when it is justified and explained can one be said to possess true knowledge. Importantly, the need to insist upon this higher standard is all the more crucial when we are working to develop knowledge of tools (such as logic, quantitative reasoning, research design, and statistical methods), as these can then form a foundation to build further (justified and explained) knowledge; if the foundations are shaky, you will never be able to trust the upper floors.

I would like to challenge all of you to develop actual knowledge concerning the material we cover — that is, to learn the methods that we think work for this or that purpose and to understand why we use them. Not everyone agrees with this level of intellectual rigor, and to be honest, others may be right: it might be a waste of your time, and you can probably get by fine in planning or even academic research by just treating quantitative methods as a series of recipes to use as dictated by the textbooks and other experts. (Of course, it is extremely difficult for an outside observer to know the difference between the two, as rote memorization of facts and blind acceptance of the formulas in the text will still get you the right answers; therefore, whether you choose to pursue true knowledge or just faith in the experts is largely up to you…)

2.4 A sappy comment to inspire you

Finally, I should mention that in addition to being useful towards meeting the MCP core requirement and your professional goals, Quantitative Reasoning is also very fun, and can be meaningful from a philosophical perspective. We’ll talk about this a little in class, and I hope you find yourself inspired you see the beauty and wonder in it all.

3 Schedule and Logistics

3.1 Lectures

Lectures take place on Tuesdays and Thursday from 11:00–12:30, in Room 4–237. Although it should go without saying, you are expected to attend these lectures. If for some reason you are unable to attend, it is your responsibility to

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3Empirical purists such as Karl Popper [Popper 2002] will be quick to point out that even with “justified and explained” beliefs we might be overstepping our bounds here — all “knowledge” is tentative at best and subject to revision based on future evidence.
figure out what you missed — including changes to the syllabus and assignments, discussions of statistics in current events, or other important announcements.

Beyond this, you are expected to participate. Rarely (I hope never) will the entire hour-and-a-half be spent as a lecture — we will have a group discussion, pursue interesting or meaningful sidetracks, listen to guest speakers and student presentations, and even occasionally play games. All of this is part of the course material, and you won’t necessarily be able to just get it later from the readings or the web.

3.2 Recitation Sections

In addition to the Tuesday/Thursday lectures, the class will meet in smaller groups each week for 90-minute recitation sections. Like the regular classes, these are mandatory (and your active participation will be even more essential in these smaller groups). Some weeks will be spent in review; other weeks will be more discussion-oriented, as we drill down into closer readings of particular studies or articles.

Sections will meet at follows:

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<td>Daepp</td>
<td>Thur</td>
<td>5:00–6:30</td>
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<td>R02</td>
<td>deSouza</td>
<td>Thur</td>
<td>6:30–8:00</td>
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<td>R03</td>
<td>Rosenblum</td>
<td>Fri</td>
<td>12:00–1:30</td>
<td>10–401</td>
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3.3 Office Hours

All of us have office hours, which we will announce in class and post online. If these times do not work for you, we can probably find another time to meet by appointment.

3.4 Feedback

Somewhere in here we wanted to be sure to mention that we actually care about your feedback, and ideally would want it during the course so we can identify problems (or opportunities) early and make changes as necessary. Please feel free to contact us with issues as they arise, either in person or through email (or even anonymous notes).

3.5 Some Required Elements

Although all of this should go without saying, the University requires us to say the following:

\[\text{Note: while you should still be able to just drop in during office hours and assume you’ll find someone, in this day and age of high-speed electronic communication it might be nice/wise to send a quick email to give a heads-up.}\]
3.5.1 Accommodation for Disabilities

If you have a documented disability, or any other problem you think may affect your ability to perform in class, please see me early in the semester so that arrangements may be made to accommodate you.

3.5.2 Academic Misconduct

Plagiarism and cheating are both academic crimes. Never (1) turn in an assignment that you did not write yourself, (2) turn in an assignment for this class that you previously turned in for another class, or (3) cheat on an exam. If you do so, it may result in a failing grade for the class, and possibly even suspension from the college.

At times you will be asked — and even encouraged — to work in groups, typically in the early stages of an assignment. While it is fine to discuss your work and share ideas, please be sure that anything you hand in represents your own individual work (and if necessary, credit others who have contributed significant elements). If you have any questions about what constitutes plagiarism, please consult MIT’s guidance on Academic Integrity and/or speak to a member of the teaching team. Anyone caught cheating on an exam will be reported to the provost in line with recognized university procedures.

4 Requirements

You need to (a) read all the readings, (b) complete all the assigned assignments, (c) attend all the classes (and participate in the discussions), (d) take all quizzes, and (e) otherwise think about, remember, and learn the material.

4.1 Books and Readings

For every class listed in the Outline below you will see certain readings listed. Please do these readings before the class for which they are listed, and come prepared to discuss them.

The readings are all listed in the “References” section at the end of this document. In general, they can be grouped into the following categories:

4.1.1 Required books

For most of the basic material in the class, we will be using a textbook and four short monographs, all of which are available at the Coop and on reserve at Rotch Library. Please note that the first book covers most of the general “statistical methods” part of the material, and is not that different from many other introductory textbooks. Depending on your interests and learning style you may find it helpful to rely on some other book as your “primary text,”

Note: it will be hard to cheat on an exam in this class, since we don’t have any.

https://integrity.mit.edu/
although you should be sure to look over this one as well to see how we are ordering and pacing the topics.

1. *Statistics in Plain English*, Urdan 2017: This is just what it sounds like: a straightforward text covering statistical methods for the general reader; it’s also pretty reasonably priced, which is great. We will rely on this book for formulas and computational problems. (Unfortunately, the book does not contact many practice problems, but pretty much any old-style textbook will have hundreds of those for students eager for more practice.)

2. *Exploratory Data Analysis*, Hartwig and Dearing 1979: This short book provides a classic introduction to the world of Exploratory Data Analysis (EDA), as pioneered by statistician John Tukey. Rather than rushing to statistical tests and regression analysis, EDA encourages the statistician to explore data first through descriptive summaries, plots, and other visualization techniques, to suggest both problems and relationships. This is a classic, part of the excellent Sage monograph series in Quantitative Applications in the Social Sciences; it is used in many introductory courses, and there are probably many cheap copies on Amazon and elsewhere.

3. *Visual and Statistical Thinking*, Tufte, 1997b: This small pamphlet reprints chapter two from Tufte’s larger work, *Visual Explanations: Images and Quantities, Evidence and Narrative* (Tufte, 1997a), so if you already have that, don’t bother to buy this. Due to the importance of the visual quality of the material, we are including this as a “required book” (as opposed to simply including it in the reader, which would probably cost you just as much and result in a substandard copy). It is only $7.00 and is a great intro to the endlessly-fascinating and graphically-stunning world of Edward R. Tufte.

4. *Understanding Multivariate Research*, Berry and Sanders 2000: The treatment of regression analysis in our basic text leaves something to be desired — it is more mechanical, and skips too quickly over questions of assumptions and interpretation of results. This short book was written for just this sort of class: a social science setting where students were not expected to learn everything about regression, but would need to know how to interpret work done by others and distinguish between meaningful results and junk science. Chapter five in particular gives a step-by-step critique of regressions presented in journal articles, very similar to what you will be asked to do (in part) in assignment #5.  

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7 even cheaper used on Amazon  
8 Unfortunately this book costs $30 for a pretty short intro, but I think it is very good, and it presents some nice complex examples to demonstrate the points it is trying to get across. This book was written with exactly this sort of audience in mind — students in the first year of a program who may or may not go on to more advanced courses, but need to get a firm grasp of multivariate regression fast, to be able to make sense of research presented in other substantive courses.
4.1.2 Articles and individual chapters

Beyond these books, most weeks include a few additional readings from other sources. Sometimes these will be a chapter in a book that covers a topic particularly well, or adds some interesting wrinkles to the standard treatment. Other times it will be an article or news item that demonstrates a particular concept, or gives a case for us to discuss. Remember: planners (and other professionals) spend very little time reading textbooks — most planning knowledge comes in the form of journal articles, case studies, publications of research findings, government reports, and other such sources. Typically these are less dry than text books, but they are also often written with a particular agenda or bias. Learning to read these sources in an open-minded but critical way is a real art, and an important part of a good planning.

Almost all of the readings are available on Stellar and on reserve at Rotch Library.

4.1.3 Recommended books

The “References” section also includes some recommended books that may be helpful. Some are more basic than the texts we are using (e.g. Moore and Notz [2009] Gonick and Smith [1993]), and some go into more depth on particular topics (e.g., graphs and charts; statistical software packages). Also, many of the required readings represent individual chapters from longer books — these can be good sources for further study (Zeisel [1985] and the works by Tufte in particular are worth looking at.)

4.2 Computers and Software: Putting the “R” in “QR”

Part of working with quantitative data is becoming comfortable using computers for data analysis. In this class and in the readings you will learn the theories and methods behind statistical analysis, and we will demonstrate how one can do these computations “by hand” with small samples; in an actual planning, policy, and social science situations, these computations — even the creation of simple tables and exploratory plots, to say nothing of statistical tests and regression analysis — would be extremely time consuming without the use of a computer and a statistical software package. As part of the class — although not the primary focus — you are expected to become familiar with the use of a statistical software package.

Our objective in requiring you to use a statistical package stems from the hands-on nature of the class (and the MCP program in general). By the time you finish the class, you should be able to manage large and small datasets, import them into a software package, and produce descriptive summaries, plots, and inferential analyses (including regression models). Beyond this, I hope you will apply and hone the more general purpose skills of a planner in regard to computing: striving to be resourceful in identifying both data and technical assistance; becoming comfortable across platforms and settings; understanding and questioning the assumptions inherent in any analysis you encounter or
conduct; and interpreting and presenting the results of your work to a general audience.

Choosing a particularly statistical program is similar to choosing an operating system or word processor (or bicycle, pajamas, or other tool): it is as much a matter of personal preference as an evaluation of technical merit. For this course, we have elected to encourage and support students in using a statistical package known as R:

A little framed box with info about R

R is the open source version of the commercial S and S+ programming language used by many professional statisticians and applied scientists. It is available under the GNU license, with hundreds of additional packages and extensions for free download via the CRAN website (http://cran.r-project.org/). R provides a fully-featured statistical package for data management and manipulation, statistical analysis, scripting, simulation, and graphing (the latter being a real strength). The interface is a little different if you are not used to using the command line for this sort of thing, although there are graphical user interfaces available as well (“GUIs” — windows with menus and that sort of thing). R is also installed on all the CRON computers, if you want to check it out. (Note: R is not very common (yet) in government planning offices either, but it is free, so you can bring it with you wherever you go.)

However, given the personal nature of programming, and our firm belief in the importance of cultivating resourcefulness, creativity, and the skills for critical assessment, we are giving you a choice as to which statistical package to use, R is not a hard-and-fast requirement of the class: if you prefer to use a different tool — SAS, STATA, SPSS, or other statistical program — you should still be able to complete all assignments and succeed in the course. The only caveat is that we cannot promise to support all of these options — the class examples and clinics will only deal with R.

4.3 Developing confidence through p-sets, lab-exercises, and quick quizzes

After some introductory material on the ways planners create, find, and use data, the course will dive into some pretty technical stuff: as you’ll see in the Outline below, most of the month of October is devoted to understanding the fundamentals of probability and various statistical methods for data management, summarization, exploration, and analysis. These techniques form the back-bone of good quantitative research, prediction, and thoughtful decision-making, and you will make use of them in the second half of the course, in your final project, and for the rest of your career in planning.

9 Note that Excel and other spreadsheet-based applications are not suitable alternatives — see section 5.2 on page 11.
To help ensure that all students become comfortable with these essential basics, you will be asked to complete a number of short, problem-based assignments, which will be followed by short in-class quizzes on the material. To help integrate the computing tools as you learn, assignments will also be paired with short computing exercises, which can be completed either in weekly sections or on your own.

Importantly, although they are required, these “problem-set” assignments and quizzes are not intended to be stressful: they are provided as learning tools, not implements of torture or filters to assess your worth as students or human beings. Please view them as opportunities to honestly assess what you know and where you still need to make sense of the material (or maybe ask for help).

There will be no final exam — just a final project due at the end of the semester, where you will be able to practice and demonstrate what you’ve learned.

4.4 Assignments

More detail will be given out in class and on Stellar, but in brief the assignments are as follows:

- **Assignment #1: Operationalizing Planning Concepts** Before we can apply any quantitative reasoning and statistical methods to answer policy and design questions, we must first figure out how to turn planning concepts into quantifiable data. For this assignment, you will work with a small group (4-5 students) to discuss possible ways to measure some quality or concept associated with planning questions from a list given to you (e.g., density, health, poverty, etc.). Then, working on your own, you will prepare your thoughts and recommendations in a short paper. (3-4 pp.; due 9/20/18)

- **Assignment #2: Descriptive Techniques, Summarizing Data** A short problem set and lab exercise on summary statistics. (Due 9/27/18; followed by corresponding in-class quiz.)

- **Assignment #3: Probability and the Normal Curve** A short problem set and lab exercise on calculating probabilities and working with various theoretical distributions, including the normal curve. (Due 10/16/18; followed by corresponding in-class quiz.)

- **Assignment #4: Basic Inferential Statistics** A short problem set and lab exercise on confidence intervals and tests of significance. (Due 10/30/18; followed by corresponding in-class quiz.)

- **Assignment #5: Critical Reading of Research Results** You will be provided with a small collection of papers or journal articles reporting the

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10 Assignments 2, 3, and 4, described in the next section.

11 Each of these three quizzes will be given on the day that the corresponding problem set is due; p-sets and quizzes will be graded and returned together.
results of quantitative studies, and asked to summarize and critique one, explaining the results to a layman as well as posing questions, challenges, and recommendations for further inquiry. (3–4 pp.; due 11/13/18; also due with this assignment will be a short lab exercise on regression.)

- **Final Project: Data Analysis Exercise** For the final paper you will pose your own research or policy question, and then gather and analyze data to answer it. Due to the size and nature of this assignment, the “final project” actually consists of the following stages:

  **Proposal** Prior to starting on the project, you will be asked to submit a clear and thoughtful proposal for approval, indicating your topic and key questions, the data you intend to use, and a basic outline of the steps you intend to follow. *(Due no later than 11/1/18)*;

  **Initial Draft with Peer Review** During the week of 11/26/18 you must present a draft of your initial findings to a classmate (assigned by the teaching team, based on your proposal) and meet with this student to discuss each of your projects; by 12/3/18 you will provide brief written feedback to each other to incorporate into your final papers. *(You will also be expected to submit a rough “progress draft” of your paper on Stellar by the end of the week.)*

  **Presentation** During the penultimate week of class, you will be asked to present the key findings of your project to a group of your classmates.

  **Final Draft** The final draft of your final project is due in class on 12/11/18. Please be sure to include discussion of both methodology and findings; graphs or charts; a well-documented dataset and log from your analysis; and a discussion of the peer-review comments you received and how you modified your project to address these concerns. *(No strict page limit, but probably 8–10 pages is a good target.)*

**4.5 Grading**

Your grade for the class will be based on the following allocation:
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<tr>
<td>Participation</td>
<td>20%</td>
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<tr>
<td>Assignment #1</td>
<td>10%</td>
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<td>Assignment #2 + Quiz</td>
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<tr>
<td>Final Project: Proposal</td>
<td>5%</td>
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<td>Final Project: Presentation</td>
<td>5%</td>
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<tr>
<td>Final Project: Timely Draft Completed</td>
<td>2%</td>
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<tr>
<td>Final Project: Peer Review Comments</td>
<td>3%</td>
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<tr>
<td>Final Project: Final Submission</td>
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Total 100%

5 FAQs

5.1 What if I can’t make [a deadline/a class/etc.]

We are handing out this course schedule now, at the very beginning of the term. Please look at it and note the deadlines for assignments. If for some reason you cannot meet these dates, it is your responsibility to contact us as far in advance as possible to make alternate arrangements. Extensions are generally fairly easy to grant with good cause; extensions at the last minute (or after the deadline) are much harder to justify.

5.2 Why can’t I just use Excel®?

This question always comes up. Excel is a great program for assembling, viewing, and limited manipulation of spreadsheets. Where Excel fails is where it is pushed too far; this tends to be Microsoft’s biggest mistake, in my book: they want to make a single giant tool that does everything for everyone and controls 100% of your time (and the market). In contrast, statistical packages (such as those listed in section 4.2 on page 7) have been designed around functions specific to the tasks at hand: managing large data sets; conducting complex statistical analyses (with options to control for different assumptions and technical corrections); producing high quality graphical and tabular output; and logging all inputs, commands, options, settings, manipulations, and outputs (necessary to replicate results for true scientific peer review, as well as useful for scripting and “batch” processing of routine projects).

12Includes timely preparation of readings and problems, undivided attention and thoughtful participation in lectures and sections, and a willingness to contribute to the class and help your fellow students learn as much as possible.

13Although free and open-source options are of course available that are just as good and leave a better taste in your mouth about being part of an open and free society...
In the same way that most of you would probably choke if asked to use Word to create websites or Publisher to create GIS maps, trying to use a spreadsheet for statistical analysis is overextending the technology, resulting in more work for you and a worse product in the end. You came here to expose yourself to new things and learn about planning technology; here is your chance.
6 Course Outline

Week 1: Introductions (to Each Other and to Core Concepts)

9/6/18 Course overview; epistemological foundations; math review

If you’re rusty, this would be a good time to review some of your basic math skills: order of operations, dealing with exponents, square roots, multiplying fractions, using algebra to solve for \( x \), calculating the slope of a line, and stuff like that.


Week 2: Planning Numbers; Descriptive Statistics

9/11/18 What’s in a number?; basic numeracy; measurement


9/13/18 The use of numbers in planning


Week 3: Data and Distributions

Note: please prepare readings prior to the class in which they are listed.
9/18/18 Variables; samples and populations; measures of central tendency

9/20/18 Measures of variability and dispersion
DUE: Assignment #1

Week 4: Getting, Managing, and Exploring Data
9/25/18 Statistical software; data management
You may also want to check out one of the many free online R tutorials — Coursera, DataCamp, edX, Springer’s “UseR!” series, etc.

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15This is a truly great classic in the field, and definitely worth owning, even if we don’t get to read the whole thing. You can probably find an old copy on Amazon or elsewhere, but be warned that not all editions have the chapter on Regression Analysis (the 1985/sixth edition does).
9/27/18    Exploratory data analysis and visualization

DUE: [Assignment #2 + Quiz]


Week 5: Inferential Statistics, Probability, and the Normal Curve

10/2/18    Basic probability


10/4/18    The normal curve; sampling


Week 6: Estimating with Confidence; In-Class Assessment

10/9/18    Columbus Day Holiday

10/11/18    Estimates and confidence intervals


Week 7: Science, Logic, and Hypothesis Testing

10/16/18    Logic, experiment, and the scientific method

DUE: [Assignment #3 + Quiz]


10/18/18    The idea of a statistical test; t-tests and non-parametric tests


Week 8:  Introduction to Bivariate/Multivariate Data

10/23/18  Cross-tabulations; $\chi^2$ tests

10/25/18  Scatterplots; correlation; cause and effect; confounding variables

Week 9:  Regression

10/30/18  Simple regression
DUE:  Assignment #4 + Quiz

11/1/18  The assumptions of regression analysis
DUE:  Final Project: Draft Proposal

Week 10:  More regression

11/6/18  No class (New England Patriot’s Day)
11/8/18  Multivariate Regression
To come (worked regression examples)

Week 11:  Multivariate Regression; Census Data
11/13/18  Multivariate Regression (cont.)

DUE:  
Assignment #5 + Regressional Lab

To come (worked regression examples)

11/15/18  Special Topic: The U.S. Census


11/20/18  Special Topics: Talking Dollars and Sense


11/22/18  Thanksgiving (no class)

Week 13:  Making Decisions

DUE this week:  Final Project initial draft to Stellar; meet with peer-reviewer
11/27/18  Decision Trees, Expected Utility, Cost-Benefit Analysis

11/29/18  Predictions and Uncertainty; Representing Risk

Week 14:  Presenting Data and Results
DUE: 12/3/18  Final Project: Peer-Review Comments
12/4/18  In-class presentations

12/6/18  In-class presentations

Week 15:  Wrapping it up; Parting Thoughts
12/11/18  Final Class
DUE: 12/11/18  Final Project
References


Barbara Illowsky and Susan Dean. Introductory Statistics. Rice University OpenStax, 2017. available free online: https://openstax.org/details/introductory-statistics


Michael R. Matthews, editor. The Scientific Background to Modern Philosophy: Selected Readings. Hackett Pub Co Inc., 1989. Recommended only; on reserve at Rotch, but you might as well buy it at the Coop or on Amazon—it’s only about $9.00, and it’s a great book to own.


