DRAFT
Quantitative Foundations of Public Policy
PA 325 / Summer 2013 / 94350

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Class hours: Monday, Tuesday, Wednesday, 6:00 – 8:30 pm, SRH 3.122. There may be
             a couple of exceptions; we'll talk about it on the first class day.
Office hours/Spelman: Friday, 9:00 – 12:00 am, Spider House Café, 2908 Fruth Street.
                 Also after class and by appointment.
Office hours/Choi: Time and place to be determined.

What is this quantitative stuff and why should we bother with it?

       Most of us got interested in public policy because we read the newspaper or
watched the news on TV, and got excited about public problems. Maybe you watched a
presidential debate, maybe you read David Brooks or Paul Krugman, maybe you just
talked about this stuff at the dinner table. (Maybe, like me, you argued politics with your
father every night.) But political discussion – and the prospect of participating in that
discussion in a meaningful way – is what pulled us in.

       As most people talk about it, public policy sounds like an easy choice between
stark alternatives based on values. Political leaders, commentators, and parties structure
this discussion for us; if we know which side we're on, we know where we stand. It all
sounds pretty easy. But if you're going to do this stuff for a living – and the fact that
you're here means you're at least considering it – you'll find that the devil is in the
details. Let me give you a couple of examples.

       Today's big news: Santa Monica Community College is raising tuition – but only
on the most popular classes.[1] The idea comes from basic economics: As the recession
has staggered on, demand for classes has gone up; the college, strapped for cash, has had
to cut back on the supply of classes offered; the predictable result is a long wait list,
especially for the basic classes in English and math that everyone needs. To reduce the
wait list, the college has raised tuition – the price – of these classes to raise money and
restrict demand to only those students who want them most.

       From the college's viewpoint, this is simple economics. Raise the price, clear the
market, eliminate the waiting list. Problem solved! Of course, this only works if SMCC
knows *how much* to raise the price, the probable effect of the price increase on demand
for popular classes and for (relatively cheaper) unpopular classes, and the availability of
teachers to teach the extra sections the college can now afford to offer. It's complicated.
From the student's viewpoint, it's even harder. Suppose you want to take a popular

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[1]   "Community college to charge more for top courses," *New York Times,* 29 March 2012.

(expensive) class, but could substitute an unpopular (cheap) one, instead. Should you do that? What if you want to take four popular classes – should you substitute cheap classes for all or only some of them? Quite apart from the individual choice problems, there's the ethical problem: Especially since community colleges are supposed to provide education for all (including the poor), to what extent will this provide high-priced, high-quality education, but only for those who can afford it? Maybe only a little, but maybe a lot.

Here's another example. My own work concerns economic incentives offered by state and local governments. To make a long story short, if you want growth, you offer incentives to industries you've already got – grow what you know. If you want stability, you need to diversify the economy, offering incentives to industries you haven't got. But the world isn't as simple as this on/off switch. What's the right balance of growth and stability for a particular city? Most incentives are wasted on firms that would have expanded or relocated without them. How much should local government be willing to spend on them? Of the gazillion ways to diversify a city's economy, which is best?

I could go on, but you get the idea. In health care, public safety, education, housing, defense, whatever, it's pretty easy to lay out a basic policy. But sooner or later, some *apparatchik* will have to implement it. That means making a thousand little decisions. And that means doing the math. For better or worse, that's our job.

This course is designed to give you the basic mathematical tools needed to understand, work with, and eventually create the kind of models that drive public policy decisions. We'll remind you of your (perhaps forgotten) algebra, run through the basic ideas of differential calculus, and think through the use of probabilities and statistics. You probably won't feel comfortable going toe-to-toe with Paul Krugman (who, as the Nobel committee reminded us, was an excellent international economist before he became a rich and famous pundit). But you will have the background to take on graduate work in public policy. In a year or two, you may very well be able to take on Krugman. (Certainly you won't need to repeat yourself so often as he does.)

I'm presuming you haven't taken a course in calculus or statistics, and have forgotten most of your high school algebra. Even if your algebra is bomb-proof, you remember some calculus, and you understand some basic statistics, I think you'll find the way we think about these subjects in the public policy world to be a little more interesting and a lot more practical than the substance of the average math class. Certainly that's my intention. If this doesn't seem to be working out, please feel free to let me know along the way.

Course assignments

Quantitative analysis is a lot like riding a motorcycle or playing the saxophone: You can talk about it all you want, but you won't really understand what you're talking about until you do it. In this class, you will do a lot of quantitative analysis, much of it in

class. After we work through some problems together, you'll know right away whether you're getting the idea. In addition, there will be the following take-home assignments:

> **Four problem sets.** Think of these as extended homework assignments. You will have about a week to complete each problem set, and you should feel free to work on each one in groups. In each problem set, I will ask you to use mathematical methods to make, explain, and justify public policy decisions.

> **Exam.** Although you will have 24 hours to complete the exam, it will be designed to be completed in three. (Really!) Books, calculators, computers, and any other decision aids are allowed and encouraged – but you are on your honor to work the exam by yourself or with no more than one other member of the class. I can send you the exam via email, or we can arrange for you to pick it up from some central location, anytime between 7 and 10 July; it'll be due, in paper or electronic form, 24 hours after you pick it up. The exam will cover all course material. (See *Course Objectives,* next section, for a complete list.)

Taken together, the problem sets will account for 60 percent of your grade; the exam will count for the remaining 40 percent. If you bomb one of the assignments, I will discount it somewhat.

To complete the problem sets, you will need to learn how to use a computer spreadsheet called Microsoft Excel (hereafter called Ms. Excel, not necessarily with affection). Think of Ms. Excel as though she were your third-grade teacher: nice and well-meaning, but not especially bright and too finicky by half. A lot of what we'll talk about are the same kinds of things you talked about with your friends in the third grade – how to put things over on Ms. Excel when she's not looking, how to manipulate her into doing things she doesn't really want to do, how to ask her the same question several different ways until you get the answer you want, and so on.

If she's such a pain in the neck, why bother with Ms. Excel? Because, for better or worse, she's the best third-grade teacher we've got. Ms. Excel can help us with all the things we'll be talking about this semester – algebra, calculus, probability, and statistics. She's particularly good at drawing pretty pictures, if you ask her nicely and don't expect too much. You can do absolutely everything we'll talk about in this class by hand (that is, with pencil and paper); you can even get by without a calculator. But by the end of the month I think you'll agree that Excel will help you solve most of the problems we'll deal with here. Jaehee and I will do what we can to make this as painless as possible.

Previous students have told me that I give problem sets and exams from Hell. Although this is apparently accurate information, please recognize that I don't do it on purpose. I will try to debug the problem sets in advance so they are clear, straight-forward, and require a reasonable level of work. Let me know if you think I've fallen

short of this goal – but also recognize that the best way to learn this stuff is to do it, and that most people learn best when they are challenged.

Please don't worry about grades. Yes, this is an undergraduate course, so I reserve the right to give grades along the full spectrum. Nevertheless, if you do your job and I do mine, all of you will get an A or a B. If you all learn the material well, you will all get A's (there's no curve). But for the majority of you who are already in graduate school, it doesn't matter, because no one either of us respects will ever ask you about your grade in this course. So I've already given grades more attention than they're worth.

Reading

This course is unique to the LBJ School, and no textbook covers all the important topics. All of those that come close have their own peculiarities, and the trick is to find, not the perfect book, but the one with the least intrusive flaws. The book I'm asking you to read has (I believe) flaws most of us can live with.

Stefan Waner and Steven R. Costenoble, *Finite Mathematics and Applied Calculus*, 5th ed. (Belmont, CA: Brooks/Cole, 2010), gulp, $230 or so.

This book is a best-seller, at least by the lenient standards of the college textbook industry. It explains things well in a variety of ways and uses *lots* of examples. It relies heavily on Excel (just like we will). It covers most of what we'll be talking about in this course. Perhaps most important, because it's the 5th edition the authors have gotten most of the bugs out of it. Naturally, it will cost you roughly a month's rent. If you're worried about the price (I would be), the 2nd, 3rd, and 4th editions are almost exactly the same as the 5th, and used copies are available on Amazon.com starting at $4.94, including shipping. Just be careful to get the textbook and not the student workbook, and make sure you get *Finite Mathematics and Applied Calculus,* not *Finite Mathematics*. The second title is a little cheaper, but doesn't have the calculus chapters in it. You'll need them!

Different books speak to different people, and you may not like this book one bit. If so, come talk to me so we can find an alternative. I'll put other books that cover most of the same material in one of the PhD student's carrels on the 2nd floor. It won't be difficult to find something that speaks your language. So let's not obsess over it.

Even a 1,000-page book can't cover everything, so there will be the usual assortment of textbook-like readings, made available on electronic reserves (ERes, pronounced "EE-rez" for short). To access the reserves for this class, direct your web browser to http://reserves.lib.utexas.edu/eres/courseindex.aspx?page=instr (or just search the UT web site for "ERes"), and follow the menus to find this class. You'll need a password, which I'll give you in class, to avoid legal squabbles. Most of the readings will be available in Adobe Acrobat (pdf) format, and you should feel free to download and read

them in your copious free time. If you run into any trouble, ask a classmate, Jaehee, or me, and we'll walk you through it.

When things go wrong

We've all been through enough good classes and bad classes to know the difference. In the best ones, everything goes right: We all agree on the importance and relevance of the subject; the readings, lectures, assignments, and your classmates all help you gain a mastery of the material; you feel you're accomplishing something of value. That's where *you* want to be, that's where *I* want you to be, so our objectives here are identical.

It doesn't always work that way, of course. Sometimes, you encounter what we might call a systemic problem. You don't think you're learning anything. Nothing appears to be relevant. The textbook stinks and the reserve readings are confusing. You decide I'm a disorganized slob who hates students. All this is pretty basic stuff, but we can do something about pretty much all of it. (OK, we can't do much about my idiosyncratic personality, but perhaps we can figure out how to come to terms with one another!) If you find yourself thrashing through anything this basic, let me know right away. Dash off an email; come by my (virtual) office; call me up in dreamland, radio to me, man. I'll do whatever I can to work through any of these basic problems whenever they come up.

Most of your problems won't be this basic. Instead, they'll be focused on specific stuff. You've solved three equations with three unknowns three times, and gotten four different answers. You can't figure out which of the differentiation rules to apply. You've gone over the reading three times and the central limit theorem is still as transparent as Linear B. When this happens – and it will – try the following:

1. Don't panic! Everyone gets through this, and you will, too.

2. Think hard about the problem. Read the offending material or problem carefully. Find a similar problem and apply Polyá's problem-solving process (covered on the first class day) explicitly and (no, I'm not kidding) do it out loud. Find a private place first, so your friends don't think you're losing it.

3. If that doesn't work, talk to your classmates. Different people find different problems easy, and you'll probably have a chance to return the favor before the summer's out.

4. If your classmates are mystified, too, then I probably screwed up. Since I mystified you in the first place, however, talk first to Jaehee, in a review session or during office hours, and ask for an alternative explanation.

5. If the TA can't figure it out, then justice demands that you give me a hard time. Come see me after class or during office hours, or make an appoint-ment. Bring your friends, so that we can all work out the problem together.

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If you're like most people, you learn best when you teach yourself. Don't short-circuit the process by asking for help too soon! If you really do get stumped, of course, it's our job to help out. Feel free to call on us when it's time.

Exception: The problem sets and final exam were designed to be clearly worded and straightforward. When the problem is clear, but you don't know how to solve it, follow steps one through four above. But when the problem itself doesn't make sense, please don't waste your time trying to read my mind! Ask Jaehee or me, and we'll set you straight right away.

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Course Objectives

Goal

At the most basic level, the goal of this course is pretty simple: Give you the tools you need to begin a rigorous public policy education. A lot of this is specific and procedural. What are the steps involved in estimating the minimum point of a nonlinear cost function? What data do you need and how do you use them to calculate a 90% confidence interval for a mean? As you work through each of these specific problems, I think you'll pick up a few more general things, too. In particular, you will learn to

Recognize patterns and principles when thinking about a messy problem, and be able to use these patterns and principles even if you don't crunch a single number;

Realistically evaluate your areas of knowledge and ignorance about a problem, and sort out which areas of ignorance are most critical;

Explain the thinking behind your calculations so they can be understood by people who haven't taken this course.

This kind of "mathematical sophistication" (or at least "mathematical literacy") will come all by itself. I won't discuss this in any detail, and there are no chapters in the textbook that talk about them directly. But improving your comfort level with math and statistics is an important course goal. In a few weeks, you might look back and see if you don't agree. OK, now for the specific stuff.

Introduction

Know and use Polyá's problem-solving model to solve mathematical and statistical problems.

Algebra

Use the basic rules of algebra to solve calculus, probability, and statistics problems, including simple problems involving logarithmic and exponential functions.

Interpret linear regression and correlation coefficients and explain the linear models on which they are based.

Explain what e is, where it comes from, and why it's so valuable in public policy research.

Explain what a logarithm is in terms Rick Santorum could understand.

Given n equations and n unknowns, use algebra, Ms. Excel Solver, or (conceivably) Gauss-Jordan reduction to solve for the unknowns. If it can't be done, explain why.

Calculus

Take first and second derivatives of simple nonlinear functions. Describe the meaning of these derivatives.

Graph simple nonlinear functions. Point out minima, maxima, and points of inflection. Identify the concavity of each part of the functions.

Apply methods of differential calculus to unconstrained economic optimization problems with an arbitrary number of variables.

Apply the method of Lagrange multipliers to solve constrained economic optimization problems. [This is highly optional and we may not get to it; let's see how it goes.]

Probability

Add and subtract probabilities for
        independent events
        dependent events

Calculate joint, marginal, and conditional probabilities from a simple table. Or, given the probabilities, construct the table.

Given base rates and conditional probabilities, flip trees, read tables, or (ugh) do the algebra to solve for posterior probabilities. (That is, be able to use Bayes' Theorem.)

Know why you don't know as much as you think you do and adjust for it.

Statistics

Given a batch of numbers, create a histogram, seven-number summary, and box plot. Use these summaries to describe the shape of the distribution and to compare it to other distributions.

Calculate and use the principal measures of central tendency (mean, median, mode) and variability (standard deviation, inter-quartile range, and range).

Calculate the skewness and kurtosis of a batch of numbers, and describe how these affect the shape of the distribution.

Compute expected probabilities for binomial random variables. Interpret the meaning of these probabilities in the context of a policy problem involving the Bernoulli (binomial) process.

Use a standard Normal table to find percentile values for a Normal random variable. Given a probability, work backwards to find the critical value of the Normal distribution.

Calculate the mean and standard deviation of a linear function of one random variable.

Given a mean, standard deviation, and sample size, construct a confidence interval for the population mean.

Given confidence intervals for any damn thing, describe what the heck they mean.

If time permits, design a method for achieving lasting peace and democracy in the Three-Quarters East.

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Rough Course Schedule

10-12 June   **Algebra**
                    The rules you remember and the rules you forgot
                    Words, pictures, and some unexpected uses for Ms Excel
                    Simultaneous equations
                    Transcendental functions: exponents and logarithms

17-18 June   **Calculus 1**
                    The idea of the derivative
                    Derivatives – the rules
                    Optimization in two variables

24-26 June   **Calculus 2**
                    More on optimization
                    Multivariate optimization
                    Optimization w/ constraints

1-3 June   **Probability**
                    Probability – what it is and how it works
                    Probability distributions
                    Conditional probability
                    Bayes' Theorem and subjective probabilities

8-10 July   **Statistics**
                    Summarizing batches of numbers
                    Distributions: binomial, Normal distribution, and maybe a few others
                    Samples, populations, and the Central Limit Theorem
                    Confidence intervals

10-12 July   **Final exam**: Pick up anytime during this period, due 24 hours later.

Caution: On the first class day, I may ask you to consider a couple of changes in the basic course schedule. The Final Exam dates will *not* change, but the rest of them might. So be sure to take the dates shown above with a grain of salt.