# Wharton MBA for Executives
# MKTG 776
# Applied Probability Models in Marketing

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## Motivations and Objectives

Over the past five decades, statisticians have developed a number of models that have proven to be highly effective in their ability to explain and predict empirical patterns within many areas in business and the social sciences. These models use some basic "building blocks" from probability theory to offer behaviorally plausible perspectives on different types of timing, counting, and choice processes. Researchers in marketing have actively contributed to (and benefited from) these models for a wide variety of applications, such as new product sales forecasting, analyses of media usage, targeted marketing programs, estimation of customer lifetime value, and even overall corporate valuation. Other disciplines have seen equally broad utilization of these techniques.

As new forms of information technology provide increasingly rich descriptions of individual-level shopping/purchasing behavior, these models offer great value to practicing managers, particularly those interested in pursuing CRM ("customer relationship management") activities. Furthermore, as more managers become comfortable with non-linear optimization techniques (using, for example, the "Solver" feature within Microsoft Excel), the specification and interpretation of these models can become a regular part of the sophisticated manager's toolkit. Taken as a whole, the methodological approaches covered in this course are well-suited to address the types of questions that are being asked with increasing frequency and interest by investors and managers of today's data-intensive businesses.

The principal objectives of this course are:

- To familiarize students with probability models and their role in marketing, information systems, supply chain management, actuarial science, operations research, public policy, and other related areas,

- To provide students with the analytical and empirical skills required to develop probability models and apply them to problems of genuine managerial interest.

- To have students develop good instincts to judge the appropriateness, performance, and value of different kinds of models in a variety of managerial settings.

- To encourage students to think critically about statistical methods and managerial perspectives that are common in certain domains but not always the best ways to approach all data-oriented decision problems.

This course is open to all students who have sufficient mathematical skills to handle the advanced methods that will be introduced and featured here. It is essential that students have a reasonable comfort level with basic integral calculus; furthermore, a mid-level probability/statistics course would be helpful too. But aptitude/motivation to learn and fully understand the methods covered here is far more important than past exposure to them.

## Course Organization and Materials

Every session will be lecture-based, with a strong emphasis on real-time problem solving, including mathematical derivations and numerical investigations using Microsoft Excel. Central to the development of the skills associated with probability modeling is hands-on experience. To this end, a set of homework exercises will be assigned for most sessions.

There is no formal textbook for the course (since no suitable book exists), but lecture notes covering most of the material presented in class will be made available immediately after each session. Most of the Excel spreadsheets used in class will be made available to the students, and some articles will be suggested as illustrations/applications of the techniques discussed. But most of these readings are just recommended – there will be no pre- or post-class reading assignments for any session.

## Teaching Approach

The methods covered in this course will be quite unfamiliar to most students at the start of the semester. As such, it is important to ensure that the first exposure is impactful and that there are opportunities to work with the materials multiple times and through multiple formats. To address these issues we will utilize a fairly unique "heads up" learning system in the classroom. The basic elements include:

- Mandatory classroom attendance
- The use of laptops in the classroom is strongly discouraged
- Presentation decks, spreadsheets, etc., will not be provided until after class
- Each session will be recorded and made available to students (in a convenient multimedia format) soon after each class session

These steps are intended to help students keep their "heads up" to focus on the main points in each session. Students are encouraged to ask questions about key conceptual issues, managerial applications, and the overall modeling philosophy; however, questions about more minor technical issues should be addressed by reviewing the presentation decks and recordings after class (and utilizing the Piazza platform to post and answer questions).

Students are expected to create their own complete set of class notes after attending each session and working through the decks/recordings. It is fine for students to collaborate on this task, but it's best for each student to create their own notes. Any kind of "divide and conquer" approach will be counterproductive for the student (particularly with regard to the final exam).

## Evaluation

*Homework (10% of final grade):* These exercises will be both analytical and numerical in nature. It is fine for students to communicate about these exercises, but every student must write up each problem independently. Completed assignments must be uploaded to Canvas; hard copy will not be accepted.

*Class Participation (10%):* Although there are no formal case discussions, students are expected to be actively engaged in the lectures, which will include frequent "cold calls" to ensure that everyone is following (and participating in) the conversation.

*Final Exam (30%):* The final exam will be a structured set of questions to assess students' conceptual understanding of the course material. It will not require any detailed mathematical derivations or extensive numerical calculations. It will be a closed-book exam but students can bring a one-page "cheat sheet" as a reference.

*Project #1 (25%):* For the first project, students will be asked to find a specific type of dataset and analyze it carefully. Papers will be graded using an innovative collaborative platform, the Wharton Online Ordinal Peer Performance Evaluation Engine (WHOOPPEE). Details about the assignment and grading process will be discussed in class.

*Project #2 (25%):* The second project will be more standardized – all students will be given a common dataset to analyze.

## Course Schedule

**Session 1 (F 8/31 9:30-12:30): Introduction to probability models**

Motivating problem: forecasting customer retention. Comparisons to traditional regression-based models: "curve-fitting" vs. "model-building." Careful derivation of a parametric mixture model (the beta-geometric). Coverage of maximum likelihood estimation and the Microsoft Excel Solver tool. Discussion about the philosophy and objectives of probability modeling.

**Session "1A" (S 9/1 7:30-9AM): Optional math/stat Q&A/review**

Completely optional Q&A session on the basic calculus, probability, and statistics issues covered in Session 1

**Session 2 (S 9/1 1-4): Models for count data**

Introduction to the Poisson process and its extension to the negative binomial distribution. Evaluating goodness-of-fit. Generalizing the model to allow for "spikes" at 0 and 1.

**Session 3 (F 9/21 2-5): More on count models**

Alternative estimation approaches for count models ("Means and zeroes" and "method of

moments"). Dealing with problems of limited/missing data: truncated and shifted NBD models. Applications to Facebook and other current real-world datasets.

**Session 4 (S 9/22 9-12): Repeated choice processes and empirical Bayes methods**

Choice vs. counting. The binomial distribution. The beta distribution as a mixture model. Parameter estimation and inference. Conditional distributions and expectations. Combining population information ("priors") with observed data for individuals. Regression-to-the-mean.

**Session 5 (F 10/19 9:30-12:30): Timing models**

Motivating problem: forecasting new product adoption. Implementing and evaluating different timing models, particularly the exponential-gamma. Dealing with grouped data and right censoring. Introducing hazard functions. Derivation and discussion of other timing models (e.g., Weibull), and the linkages among them. Exploring the interplay between timing and counting processes.

**Session 5A (S 10/20 1-4): More timing models + intro to customer base analysis**
***Project #1 (count model) due***

**Session 6 (F 11/2), Session 7 (S 11/3): Customer-base analysis**

Combining the basic building blocks to estimate models of customer lifetime value and related concepts.

**Session 8 (F 11/16): Introducing covariates**

Poisson regression and NBD regression for count models. Proportional hazard methods and covariate effects for timing models. General discussion about the different role of covariates from the perspective of an econometrician vis-à-vis a probability modeler. Applications.

**Session 8A (F 11/16 5:15-7:15): Customer-based corporate valuation**

Optional (but highly recommended) session

**Session 9 (S 11/17 9-12): Finite mixture and latent class methods**

Looking at non-parametric (discrete) approaches to capturing heterogeneity. Interpreting support points versus cluster characteristics. Estimation issues. Overview of selection criteria for non-nested models.

**Session 10 (R 11/29 9:30-12:30): Multi-item choice models**

The multinomial choice process and the Dirichlet mixing distribution. Interplay between the beta and Dirichlet distributions.

**Session 11 (F 11/30 5:15-7:15) Fun with Dirichlet!**

Close examination of the astonishing patterns arising from this model, and discussion of the Ehrenberg/Sharp "empirical laws."

**Session 12 (S 12/1 1-4): Integrated models**
***Project #2 (covariate model) due***

Combined models of counting, timing, and/or choice. Particular focus on the BB/NBD as a working example.

**Final Exam (S 12/15 1-4)**