45-924
Customer Management Using Probability Models
(a.k.a. Stochastic Forecasting Models)

Carnegie Mellon University
Tepper MBA Program

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Time and Room:
Time: Tu/Th 10:30 am to 12:20 pm
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Tuesdays and Thursdays: 1:30 pm to 2:30 pm in my office (372 Posner Hall)

Teaching Assistant:
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NOTE: This course is an elective in the following concentration areas: (1) Marketing, (2) Quantitative Analysis.

MOTIVATIONS AND OBJECTIVES

Forecasting is a critically important activity for all firms. In this course, we will learn simple but powerful models that use readily available purchasing data to capture underlying patterns in customer behavior. More importantly, we will learn how to use these models to provide accurate forecasts for what these customers will do in the future. Most importantly, we will learn the *right way to think* about modeling customer activity. Using this way of thinking, we will see that consistent behavioral patterns exist across different marketing channels (e.g., offline, online and catalog) and even across seemingly different domains (e.g., grocery and music).

The statistical tools learnt are very general in their applications and can also be used for various decision analysis applications that manufacturing managers, consultants and information technology professionals are often faced with.

First, we will use basic building blocks from probability theory to offer behaviorally plausible perspectives on different types of timing, counting, and choice processes. Following this, we will learn how these building blocks can be integrated to develop more complete models of various phenomena.

As an example, suppose we have historical data on a customer who purchases music CDs a few times every year from "click" as well as "brick" outlets of a music retailer. Given these data, how can we make sensible predictions of her future purchasing activity? In this course, we will see that a very effective way to model this is to decompose this process into three simple processes – (1) a *timing* process that determines *when* she will make purchases, (2) a *choice* process that determines *which* outlet ("click" or "brick") she will purchase the CDs from on a specific occasion and (3) a *counting* process that determines *how many* CDs she will purchase on a specific occasion. Calibrating these three processes and integrating them together will help us to develop accurate forecasts of the future behavior of the customer, which can aid in various decisions such as assessing customer lifetime value (CLV), developing customer contact strategies and inventory planning.

This course will equip the sophisticated manager with simple but powerful statistical tools that can help analyze a wide variety of typical business situations, such as in the above examples. Every class will start with a representative real-life problem which we will solve by the end of the class. To ensure that these tools remain relevant to managers, the models and techniques discussed in the course have been made to pass through the following three-step "sieve:"

(1) Do the mathematical models offer actionable marketing insights?
(2) Are the data required as input to the models available in a simple, manager-friendly format (i.e., without requiring time-consuming cleaning and pre-processing)?
(3) Are the models *fully* implementable in a standard spreadsheet package (like Microsoft Excel)?

Some of the problems we will solve in class are:

- How to project customer retention rates, such as in cell-phone contract renewals
- How to estimate exposures to billboards
- How to choose your target customers in a direct marketing program
- How to plan a reward program
- How to forecast adoption of new products
- How to calculate the future profit from customers from early activity data
- How to do the above if you have barely any data (data collection problems, privacy problems, etc.)

A major aim of the course is to teach the correct way to approach the forecasting of customer behavior. However, the techniques discussed are easily portable to applications outside marketing and we will consider several such examples. Time permitting, we will also throw in some fun examples, e.g., ranking sports stars by developing a procedure to estimate their true abilities given their performance statistics, predicting Tweeting behavior using real Twitter data, etc.

PREREQUISITES

Students need sufficient mathematical background to handle the tools that will be introduced and discussed. It is essential that students have had exposure to basic integral calculus, though we will review this in class. Furthermore, an introductory probability/statistics course would be very helpful, but is not necessary.

COURSE ORGANIZATION AND MATERIALS

Most of the classes will be lecture-based, with a strong emphasis on real-time problem solving, including analytical exercises on the chalkboard 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 some 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 distributed on a session-to-session basis. Excel spreadsheets used in class will be made available to the students, and some journal articles will be suggested as illustrations/applications of some of the techniques discussed. While it is expected that students will read and review all of these materials thoroughly, there will be no pre-class readings assigned for most sessions.

EVALUATION

Homework Exercises (40%): These exercises will be both analytical and numerical in nature. All of the numerical work can be completed using Excel (although students are welcome to use other software packages if they wish).

Class Participation (20%): While there are no formal case discussions, every class will start with a real-life problem which we will solve and implement in Excel by the end of the class. Students are encouraged to be actively engaged in the lectures and to contribute actively in developing the solution.

Term Project (25%): This project will be in consultation with the instructor. Students can: (1) choose to do a structured project where they will be asked to find specific types of datasets to analyze carefully, or, (2) choose to do a more open-ended project. The second choice is encouraged and will attract extra points. A student opting for the second choice can: (a) develop and apply a new probability model to a topic/dataset of their own choosing; (b) carry out an extensive simulation exercise to explore the properties of one or more models covered in class; or (c) conduct a comprehensive review of one application area of probability models in marketing in consultation with the instructor.

Final Exam (15%): This will be a take-home exam designed to assess the understanding of the various concepts learnt in the course and how they fit with each other.

TENTATIVE COURSE SCHEDULE

		Class topic	*Deliverables*
Week 1	Class 1	Introduction to Probability Models	HW 1 – Regression
	Class 2	Count Models	
Week 2	Class 1	Count Models	HW 2 – Excel Warm Up
	Class 2	Choice Models	and Count
Week 3	Class 1	Timing Models	HW 3 – Count and Choice
	Class 2	Timing Models	
Week 4	Class 1	Empirical Bayes Methods	HW 4 – Timing
	Class 2	Empirical Bayes Methods	
Week 5	Class 1	Covariates	HW 5 – Empirical Bayes
	Class 2	Integrated Models	
Week 6	Class 1	Integrated Models continued	
	Class 2	CLV – Framework and Contractual	
Week 7	Class 1	CLV – Non-contractual	
	Class 2	CLV – RCSS; Summary and wind up	Term Project

DETAILED COURSE CONTENTS

Introduction to probability models (1 lecture)

Motivating problem:

- Forecasting customer retention for subscription-based services at My Mobile.

Tools and Concepts:

- Comparisons to traditional regression-based models: “curve-fitting” vs. “model-building.”
- Careful derivation of a parametric model (the shifted-geometric) and introduction to a parametric mixture model (the shifted-beta-geometric).
- Coverage of maximum likelihood estimation and the Microsoft Excel Solver tool.
- General discussion about the philosophy and objectives of probability modeling.
- Highlights of the course.

Models for count data (2 lectures)

Motivating problem:

- Estimating advertisement exposures in a mass-media campaign at Big Bill$ Billboards.

Tools and Concepts:

- Introduction to the Poisson process and its extension to the negative binomial distribution.

- Evaluating goodness-of-fit.
- Alternative estimation approaches (e.g., method of moments).
- Dealing with problems of limited/missing data: truncated and shifted NBD models.
- Generalizing the model to allow for "spikes" at 0 or 1.

Models for choice data (1 lecture)
Motivating problems:
- Segmentation-based direct marketing at Ben's Knick Knacks.
- Are NFL field goal kickers lucky or good?

Tools and Concepts:
- The binomial distribution.
- The beta distribution as a mixture model.
- Parameter estimation and inference.
- Choice vs. counting.

Models for timing data (2 lectures)
Motivating problems:
- Planning a reward program at Cathy's Coffee Corner.
- Forecasting adoption of Krunchy Bits.
- Forecasting adoption of video-on-demand services at When U Want, Inc.

Tools and Concepts:
- Implementing and evaluating different timing models, particularly the exponential-gamma model.
- 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.

Empirical Bayes methods (2 lectures)
Motivating problems:
- Targeting the right customers at Ben's Knick Knacks
- Gleamo's not gone: Understanding Customer Behavior Over Time

Tools and Concepts:
- Conditional distributions and expectations for choice, count and timing processes.
- Combining population information ("priors") with observed data for individuals.
- Regression-to-the-mean.

Incorporating covariates (1 lecture)
Motivating problem:
- Who is visiting khakichinos.com?
- Impact of promotions on the adoption of Krunchy Bits.

Tools and Concepts:
- Poisson regression and NBD regression for counting models.
- Discussion of proportional hazard methods and covariate effects for timing models.

Integrating count, choice and timing models (1 lecture)
Motivating Problems:
- Forecasting repeat sales at CDNOW.
- Do you lie when you buy port wine?

Tools and concepts:
- Combined models of counting, timing, and/or choice.
- Particular focus on the BB/NBD model.

Calculating Customer Lifetime Value (CLV) (3 lectures)
Motivating Problems:
- The Perils of Ignoring Heterogeneity.
- Forecasting CLV for Caribbean Cruise Company.
- "Buy till you die" at CDNOW.
- Estimating CLV using Aggregated Data at *Tuscan Lifestyles*.
- Can we accurately estimate CLV but preserve customer privacy?

Tools and Concepts:
- Combining the basic building blocks to create integrated models to estimate customer lifetime value and related concepts.
- Classification of customer bases along dimensions of contractual or non-contractual relationship with the firm, and discrete or continuous transaction opportunities. This gives four scenarios, which we will take up one-by-one:
  1. CLV in a contractual setting with discrete-time transaction opportunities
  2. CLV in a contractual setting with continuous-time transaction opportunities
  3. CLV in a non-contractual setting with discrete-time transaction opportunities
  4. CLV in a non-contractual setting with continuous-time transaction opportunities
- Modifying basic models to facilitate implementation in Excel (focus on BG/NBD and PDO models).
- Adapting basic models to aggregated data formats, e.g. periodic histograms instead of individual-level measures.
- Adapting basic models to privacy-preserving data formats.

Conclusion (1 lecture)
- Brief summary of course contents.
- Discussion of applications outside marketing. s