

The Brattle Group

A Markov Chain Approach to Forecasting Enrollments

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Issue: How do we consistently forecast enrollments for a suite of DR programs?

- Programs compete for the same customers, so an enrollment in one program means one less prospect for the other programs
 - If Program A forecasts enrolling 25 of 35 eligible customers and Program B forecasts enrolling 25 of 35 eligible customers, then they can't both be right.
 - How do we enforce internally consistent forecasts?
- Can we find an approach that will allow sweeping changes to the environment (such as default, AMI rollout etc.) without too much complication.
- Can we scale the approach to many programs and time periods with many changes?

What is a Markov Chain?

- It is a simple equation to describe the evolution of a population changes over time
- Used in chemistry, biology, and finance.
- Describe the population at any time t by a vector s_t where coordinates enumerate the fraction of the population in a particular “state”.
- States must be exhaustive and mutually exclusive
- Describe the evolution of the population by a “transition matrix” which at row i column j enumerates the probability of moving from state i to state j

An Example

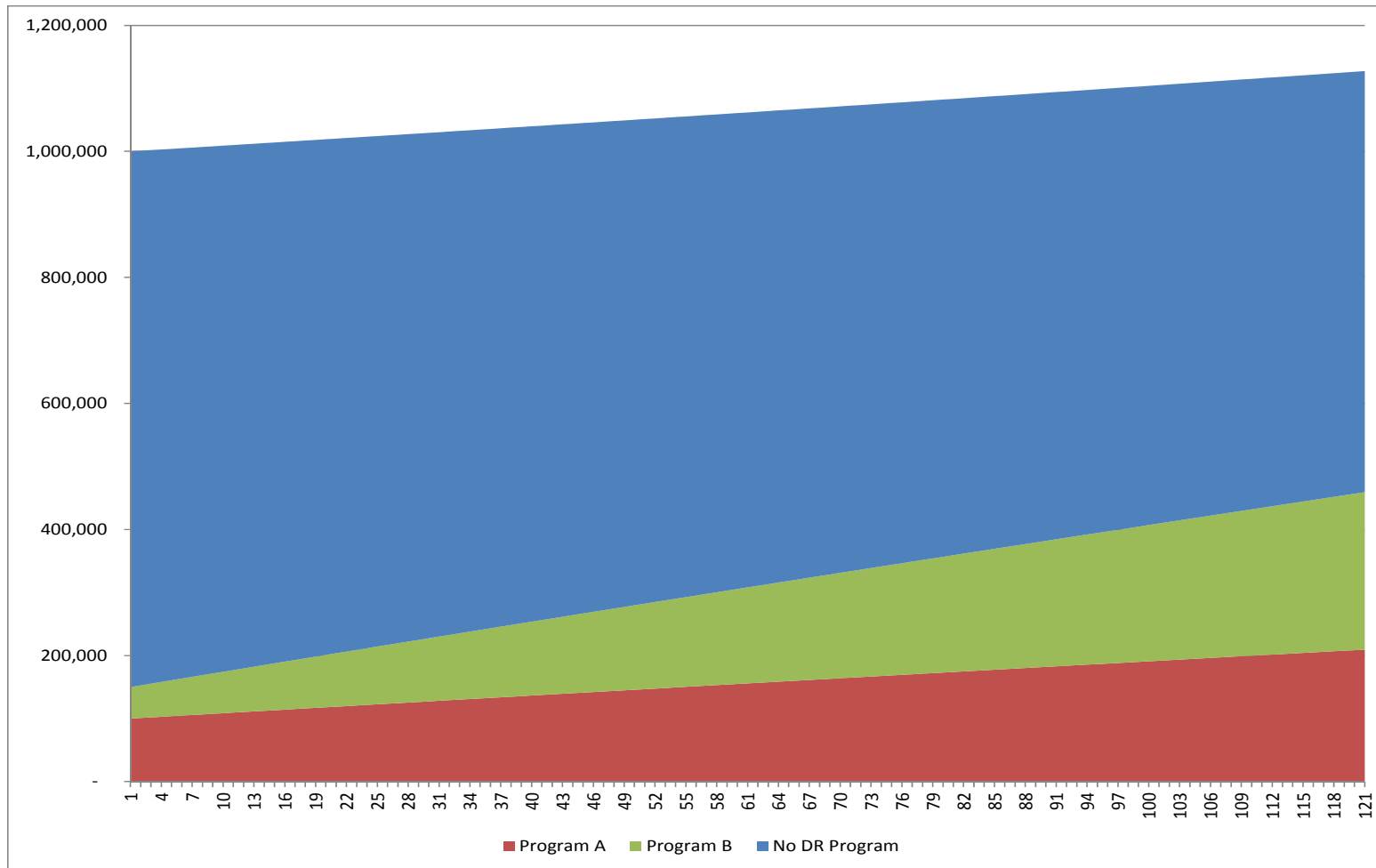
- Assume two programs A & B with no co-enrollment allowed
- No churn (no de-enrollment)
- 3 States are: enrolled in A, enrolled in B, not enrolled
- 15% and 5% of the population are enrolled in programs A & B respectively at the beginning of the forecast period
- 0.1% and 0.2% chance of enrolling a new customer each month in programs A & B respectively

$$s_1 = \begin{bmatrix} .798 \\ .151 \\ .052 \end{bmatrix} = T s_0 = \begin{bmatrix} .997 & 0 & 0 \\ .001 & 1 & 0 \\ .002 & 0 & 1 \end{bmatrix} \begin{bmatrix} .80 \\ .15 \\ .05 \end{bmatrix}.$$

The Markov Property

- The Markov property states that the transition probabilities depend only on the current state (and no past history).
- Sometimes called the “memoryless” property
- Possible to relax this assumption by complicating the state space

Example Forecast



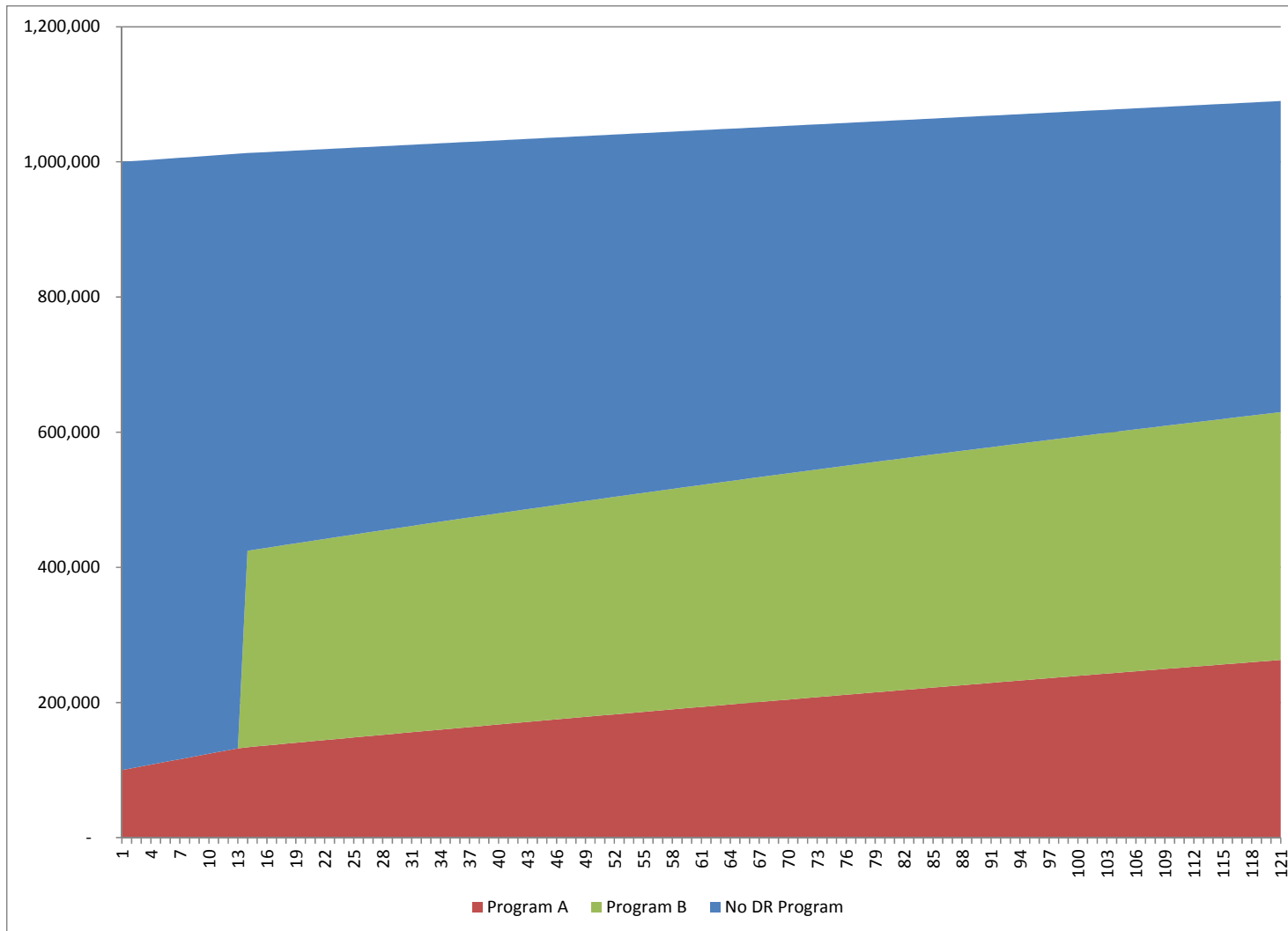
Can we make the example more complicated?

- Sure add churn: Program A participants leave to No DR with probability 0.1% per month

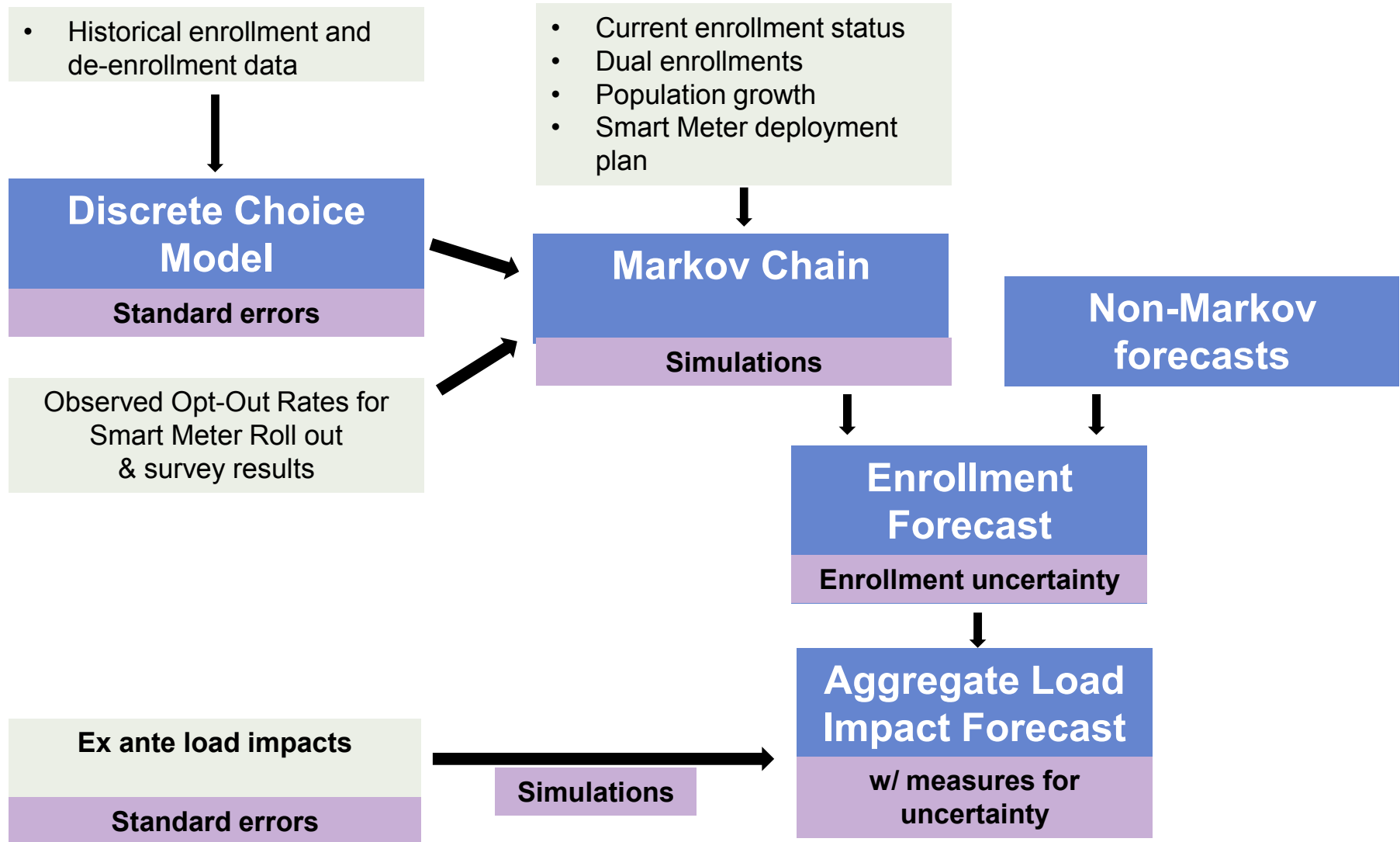
$$T = \begin{bmatrix} .997 & .001 & 0 \\ .001 & .999 & 0 \\ .002 & 0 & 1 \end{bmatrix}$$

- Add that Program B doesn't exist until a year into the forecast, then a third of those not on Program A are defaulted onto Program B.
 - We just index transition matrices by time have one for the first 12 months, another for default, then another for post default

Example with Churn and Default



The Markov Model is part of a Larger System



Where do the Transition Probabilities Come From?

- For existing programs that are not expected to change radically we can use historical data on enrollments
 - Simple: ratio enrollments over a period by eligible over the period
 - More Complex: estimate a discrete choice model such as logit for enrollment choices
- For new or radically modified programs for which there is no history
 - Survey research: “How likely would you be to enroll in a program like...”
 - Judgments of knowledgeable program administrators
 - Extrapolate from pilots if possible
 - Build up alternative from discrete choice model of existing programs

Conclusions

- The Markov Chain approach is a simple flexible and scalable approach to enrollment forecasting a portfolio of programs
- We have found it invaluable in combining forecasts for 15 or so individual programs with many policy changes in the future.
- Easy to program and adapt
- Easy to facilitate monte carlo simulations of uncertainty

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Armando Levy, Ph.D.

Dr. Armando Levy, a Senior Associate at *The Brattle Group*, specializes in microeconomics, econometrics, and statistics. Dr. Levy has provided testimony and supported the expert work of top academics in many litigation cases with an emphasis on statistical and econometric issues as well as sample design. His casework experience spans class action damages, insurance, intellectual property and telecommunications. His academic work has examined issues in the demand for crop insurance, telecommunications and live theater. He has also analyzed bidding behavior in auctions, the diffusion of wireless technologies, and optimal contracts in the poultry industry.

Prior to joining *The Brattle Group*, Dr. Levy was Assistant Professor of Economics at North Carolina State University in Raleigh, North Carolina. Dr. Levy has been a lecturer at the University of California at Berkeley since 2008.

Dr. Levy has authored a chapter for a book on demand analysis in the telecommunications industry and numerous articles for peer-reviewed journals. Dr. Levy earned his Ph.D. in Economics and a M.A. in Statistics both from the University of California at Berkeley.

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