Maritz Research White Paper

Monte Carlo Forecasting

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Abstract

Monte Carlo methods can improve forecasting efforts by explicitly accounting for uncertainty in the forecast. By recognizing, quantifying and using the range and distribution of uncertainty around all forecast input variables, the method produces a managerially useful range and probability distribution for the forecast, rather than an unrealistic point estimate. The paper uses a disguised pharmaceutical forecasting example to illustrate both volumetric forecasting and how Monte Carlo analysis improves it.

I. Introduction

Since we never know the future with exact precision, when we make forecasts for clients we can either ignore the fact that uncertainty surrounds our forecast, and then be bitten by it, or we can recognize that it exists, accommodate it in our forecast and thus tame it. One good way of taming uncertainty in forecasts uses the Monte Carlo method as described below. Other methods exist, like bootstrapping, and these will be subjects of subsequent white papers.

II. A Deterministic Forecast

A. Volumetric Forecasts

1. Create a Cascade

To illustrate the difference between a simplistic forecast that ignores uncertainty and a Monte Carlo forecast that does not, we will use a disguised case study. Transylvanian Pharmaceuticals, Inc. is preparing to launch the first in its line of blockbuster drugs for treatment of Lycanthropy. The drug "Wolfsbane 30," a once daily 30mg oral tablet, will launch first in Romania.

A volumetric forecast of sales in the first year of launch will have several components:

1. The number of physicians who treat Lycanthropy patients
2. The % of these physicians who will be aware of Wolfsbane 30
3. The number of Lycanthropy patients seen by each of these physicians
4. The % of these physicians who will be prescribing Wolfsbane 30
5. The % of their Lycanthropy patients to whom they would prescribe it
6. The % of Lycanthropy patients unable to take Wolfsbane 30 because it interacts negatively with other drugs they are already taking (e.g. garlic, in tablet or necklace form)
7. The number of prescriptions physicians will write per patient
8. The number of days of medication per prescription
9. Compliance: the % of patients who will actually get their prescription filled

2. Populate the Cascade

Now, information on some of these nine components will be available from secondary sources, like:

1. The number of physicians who treat Lycanthropy (from Romanian government sources)

9. Compliance: from Romanian government sources about typical patient compliance with similar drugs

Others of these components we can measure with survey research, using a concept testing questionnaire given to the target physician population:

3. The number of Lycanthropy patients seen by each of these physicians
4. The % of these physicians who will be prescribing Wolfsbane 30
5. The % of their Lycanthropy patients to whom they would prescribe it
6. The % of Lycanthropy patients unable to take Wolfsbane 30 because it interacts negatively with other drugs they are already taking (e.g. garlic, in tablet or necklace form)
7. The number of prescriptions physicians will write per patient
8. The number of days of medication per prescription

Finally, another component we will have to estimate based on past experience launching new drugs in Romania, and certainly with input about the advertising and PR plans for the launch:

2. The % of physicians who will be aware of Wolfsbane 30

Perhaps this is even something we could get from the client's ad agency, Talbot and Chaney Partners, based on their advertising plan for the product launch.

3. Calculate the Forecast

Now, imagine that we've collected our government statistics, performed our concept test survey of 100 Romanian physicians and made our best guesses about awareness based on past experience. From these efforts we have:

1. 300 physicians who treat Lycanthropy patients
2. 50% of these will be aware of Wolfsbane 30
3. These physicians treat 100 Lycanthropy patients each
4. 30% of these physicians will prescribe Wolfsbane 30 (after adjustments for overstatement)
5. They will prescribe to 50% of their Lycanthropy patients
6. 10% of Lycanthropy patients cannot take Wolfsbane 30 because it interacts negatively with garlic
7. 3 prescriptions per patient
8. 10 days per prescription
9. 50% of patients will get their prescriptions filled

The forecast cascade works by multiplication. We multiply all these together and we estimate that 30,375 Wolfsbane 30 tablets will sell in Romania in the first year of Wolfsbane 30's launch.

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B. Problems with a Deterministic Forecast

This is a simplistic forecast because it gives us a single number, 30,375, with no information about how much confidence we have about it or how much random error may occur around it. We KNOW that the inputs to this forecast contain uncertainty. For example, our survey measures, taking into account the fact that we're interviewing 100 from a population of 300, have a 95% confidence interval of +/- 8 percentage points. Romanian government statistics tend to be outdated (and inaccurate even when they're new). And our estimate of awareness is based on past experience that ranged from 35% to 65% for similar drug launches.

It would be naïve to think that all of our numbers are exactly accurate, or that all these kinds of uncertainty just happen to cancel out exactly. But this is exactly what we assume if we produce a simplistic, deterministic forecast.

III. A Monte Carlo Forecast

It makes a great deal more sense to produce a forecast that incorporates (rather than ignores) all the uncertainty around the forecast inputs. A method that statisticians use to incorporate uncertainty, and use it to advantage, is called the "Monte Carlo" method.

A. How a Monte Carlo Forecast Works

In a Monte Carlo forecast, we produce a large number of forecasts rather than a single one. Each of these many forecasts is a "what if" scenario. Across scenarios we let each of the nine components vary randomly within its range of uncertainty. In a given scenario, each component takes on a particular (random) value from within its possible range. We perform the multiplication above for each of these scenarios to produce a forecast. By running a large number of these scenarios, say 1,000 of them, we understand:

- The full range of possible forecasts
- The most common (or average) forecast
- And the range within which 90% or 95% of forecasts fall (the confidence interval).

If the client has some target financial goal they must meet for the product launch to be a success, we can even calculate the probability of actual sales being at or above that target.

Note that we are not performing complex statistical manipulations or formulas, we're simply taking a large number of cases, adding random variation independently to 9 variables, multiplying those variables and then looking at the distribution of forecasts.

B. Quantifying Uncertainty

Making a Monte Carlo forecast is pretty straightforward after having the components to the deterministic forecast in place. Above we already identified the components for a Wolfsbane 30 forecast and collected measures for them. Now we have to collect measures for our uncertainty around each one. As noted, the survey produces % estimates of +/-8 percentage points. For count estimates in the survey we will have to look at the actual distributions in the survey data and estimate the standard deviations. For other inputs we may have to guess (or let our client guess) how much uncertainty surrounds the government statistics and the awareness estimate.

We also need to estimate the distributions of uncertainty. We can assume that the % estimates from the survey are approximately normally distributed. For count estimates we should examine the distributions to see if they are normal or not. For the judgmental inputs about uncertainty (government statistics, client's judgment about awareness) we should use a normal distribution in the uncertainty range if we are more confident about the input, or a uniform distribution within the range of uncertainty if we are less confident.

So let's say that for the nine inputs to the Wolfsbane 30 forecast we have the following estimates, ranges and distributions of uncertainty:

1. 300 physicians treat Lycanthropy patients (+/-10%, normally distributed)
2. 50% of these will be aware of Wolfsbane 30 (+/-15%, normally distributed)
3. These physicians treat 100 Lycanthropy patients each (+/- standard error from the survey, normally distributed)
4. 30% of these physicians will prescribe Wolfsbane 30 (+/- standard error from the survey, normally distributed)
5. They will prescribe to 50% of their Lycanthropy patients (+/- standard error from the survey, normally distributed)
6. 10% of Lycanthropy patients cannot take Wolfsbane 30 because it interacts negatively with garlic (+/- standard error from the survey, normally distributed)
7. 3 prescriptions per patient (+/- standard error from the survey, normally distributed)
8. 10 days per prescription (+/- standard error from the survey, normally distributed)
9. 50% of patients will get their prescriptions filled (+/- 30%, normally distributed)

C. Completing the Forecast

We have built this Monte Carlo forecast into the workbook "Disguised Monte Carlo Forecast Example.xls." You can play with this interactive forecast tool and change some of the inputs, but our run of the distribution of forecasts with the default settings in the workbook looks like this:

> The distribution of forecasts has a mean of 31,261 units and a median of 28,771 units. The 95% confidence interval is 11,246 to 58,841. If the client needs to sell 25,000 units for the launch to be a success, then we think that there is a 61.8% chance of the launch being a success.

Clearly we are communicating more information to the client that the simple forecast of 30,375 tablet sales using the simple deterministic forecast described above. The client can see the range of possibilities left by the uncertainty in the measures. If they identify a threshold of success (25,000 tablets) we can tell them that 61.8% of the forecasts come in over 25,000 units.

IV. Summary

The Monte Carlo method provides for a much more honest method of forecasting, allowing us to be honest about the range of possible outcomes and the amount of risk (in upside and downside potential) around any single point estimate forecast. Maritz recommends this method of forecasting.

It's worth mentioning that the Monte Carlo method is a general one for dealing with uncertainty, even beyond forecasting. ROI analysis, for example, can also be better done with a Monte Carlo approach than with a simplistic, deterministic approach.

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