Passenger airlines are increasing their use of sophisticated simulation models to predict traffic volumes and market shares following changes to schedules, service levels, price changes and new route additions. The tow main types of forecast model are QSI and Logit.

Using Logit & QSI in O&D measurement

Passenger airlines are increasingly using sophisticated network simulation models to test the feasibility of proposed service changes, and optimise their network profitability. Such models are used by airline planners to quantify the impact on traffic, revenue and profitability in 'what if' network scenarios.

In practice, simulation models have many potential uses in evaluating proposed changes. These include testing the impact of: schedule or route changes; capacity changes; fleet changes; major network restructuring (such as the creation of new hubs); codeshares and alliances; or synergies from proposed airline mergers or acquisitions. The models can also be used to 'game' competitor actions and responses.

Modern network simulation models are loosely based on quality service index (QSI) or Logit methodology.

QSI was developed in the 1950s by the US Civil Aeronautics Board (CAB) to forecast an airline's market share, traffic, and operating results. QSI-based models work by estimating an airline's market share in a given origin-destination (O&D) city-pair market, based on the carrier's service offerings relative to its competitors. This estimated share is then applied to the known total passenger traffic in the market to project the number of passengers that the subject airline is likely to attract.

Today's simulation models are able to estimate share and allocate traffic across an airline's entire network, which may consist of thousands of O&D markets, in a matter of minutes. "Air New Zealand does its O&D forecasting on a QSI-based system because it is relatively transparent and easy to understand. It makes forecasting a lot easier when you clearly understand how the results are derived. Also, based on my previous experience, I was quite happy with QSI forecasting," says Peter Yap, network strategy manager at Air New Zealand. "We use our forecasting system whenever we look at adding new markets or having significant timing and/or competitive changes in a market. We use the system on a regular basis."

Benefits

What specific benefits do QSI and Logit deliver? "Lufthansa Systems offers a solution for strategic network planning and optimisation," says Bernd Jurisch, director of network management at Lufthansa Systems. "It is marketed under the product name NetLine/Plan, which uses forecasting models with both QSI- and Logit-technology. Several versions of each model technology are available. Both QSI and Logit-models are used to forecast passengers' choices for different trip alternatives on the same O&D. The use of such models enables reliable forecasts for the expected passenger flow over the available network of all participating airlines. Such models are typically used in the strategic (long-term) planning phase, for example, to optimise connectivity of an airline's network. The advantage of a QSI model is its more intuitive approach, which makes it easier to calibrate without sophisticated calibration tools. The advantage of Logit is its higher accuracy and reliability. Lufthansa Systems also offers a dedicated calibration tool as part of the NetLine/Plan package."

Jim Barlow, vice president at Sabre Airline Solutions, gives his answer in detail. "Traditional forecasting models used in today's revenue management systems are not sensitive to price, schedule, or other economic effects. Generally speaking, they are 'time series' models that estimate passenger demand based on seasonal patterns and overall trends in the industry. While these models are reasonably accurate in the aggregate (for example, 15% error), they often miss big changes such as a change in the market's fare structure or the introduction of a new competitor. As a result, a revenue management system may set its controls inappropriately since it was not given good demand forecasts.

"Allowing revenue management systems to react to price and schedule changes is where Logit or QSI models come in," continues Barlow. "These models belong to a class of forecasting models called 'causal' models. Rather than basing the forecast on trends and patterns, causal models seek to identify the underlying causes of passenger demand and use that information to produce forecasts accordingly. For example, Logit and QSI models used by leading airlines understand that airline passengers generally prefer non-stop flights over connections, prefer certain times of the day and week, and lower fares and fewer fare restrictions. The degree of preference for these effects often varies by market and passenger types, which is why today's leading airlines spend significant resources calibrating these models.

"There are two primary benefits to Logit/QSI models in revenue management systems. Most obviously, the use of these models (in conjunction with traditional time series models) will increase the accuracy of the demand forecasts thus allowing the revenue management system to make better availability decisions," continues Barlow. "Put simply, these models will react more quickly and effectively to the ever-changing nature of schedules and prices in today's airline environment. The second benefit is that these models provide some insight into passenger behaviour that can be used by revenue management systems. For example, one important variable in a revenue management system is a

Air New Zealand uses QSI models to simulate the traffic and market share it will get on its route network, and employs the system whenever it considers adding new markets.

recapture rate, defined as the probability that a passenger, having been denied space on his/her preferred flight, will be re-accommodated on another flight flown by their preferred carrier. Why is this variable important? The cost of denying accommodation for one passenger is sensitive to the chance of keeping that passenger on other flights. Logit/QSI models provide precise estimates of these rates by market and passenger type thereby allowing better revenue management decisions to be made."

Andrew Boyd, chief scientist and senior vice president, science and research at PROS Revenue Management says: "QSI and Logit models seek to understand customer purchasing behaviour by understanding the different attributes of discrete choices faced by a consumer, and how these different attributes affect the actual choice made by the consumer. As an example, the discrete choices faced by a passenger flying from Chicago to Houston include all the different itineraries that might work for the passenger. The attributes of each itinerary include fare, number of connections, length of trip, departure time, carrier and others. How you determine the most important and quantify their significance for decision-making is another important issue. These are the goals (and benefits) of different types of discrete choice models."

Joel Antolini, senior vice president at Seabury Airline Planning Group, answers this question in a different way. "QSI and Logit are both attempts to properly weight competing airline itineraries. These methods provide a relatively accurate forecast for each alternative itinerary by weighting itineraries according to their desirability. For instance, both QSI and Logit will give a widebody aircraft itinerary more weight than a narrowbody itinerary when properly calibrated. In the same way, non-stop itineraries are given more weight than connecting itineraries, because non-stops are more desirable. Either method can provide an accurate forecast if the service factors are calibrated correctly."

Dr Philipp Goedeking, partner at Competence Center Transportation of Roland Berger, focuses more on the difference between QSI and Logit. "There is no QSI versus Logit. Logit is just another way to calculate a QSI. We know there has been a heated debate on this issue, but we feel this debate was misleading or frankly wrong. The only difference is that QSI calculates a key performance indicator in the range of 0 to 1, whereas Logit calculates a likely market share in the range of 0% to 100%. The question is not which is better, but which figure is more useful for each application.

"A simplified QSI might be more straightforward for quick evaluations or optimisation purposes," continues Goedeking. "Logit, for the time being, remains as the methodology of choice as long as you want to estimate market shares, pivotal to forecast likely profitability of a future schedule scenario. The point today is that neither QSI nor Logit permit sufficient reflection of price to estimate market shares or relative performance on a given city pair (O&D) or entire network. The high importance that passengers attributed to the timetable in the past is increasingly replaced, at least on short- and medium-haul routes, by price. Hence, the marketing mix as such (interaction) must be given much more consideration today rather than the isolated constituents thereof. We are waiting for academics or companies to come up with a new methodology to cope with this problem."

Yap illustrates the benefits that Air New Zealand gains from QSI. "We generally aim for a forecasting accuracy level within 20%. That said, however, we do sensitivity analyses as part of every forecast we do to see how different our results could be. If our sensitivity analysis says that we would result in a negative profit if we are only 5% off, then we try to make the effort to make our forecasts more accurate. Or, if it is a big decision, we make sure that all relevant stakeholders understand the risks around any decisions made. The biggest contributor to forecast accuracy is a good O&D market size file as an input."

Timescale

How long does it take to calibrate the system? "Logit/QSI models have been in use in Sabre's flight scheduling and revenue management products (such as Sabre's AirFlite and AirMax) for over 15 years. Sabre continuously calibrates its models based on publicly available data and provides results to any interested airlines via a service bureau. For airlines wanting additional accuracy by calibrating time-tested models on their own internal data, the calibration process typically requires two months once the necessary data are available. Of course, Sabre recommends that calibrations be re-visited on a regular basis perhaps every six months. Re-calibrations require less time than the original calibration," says Barlow.

Jurisch provides Lufthansa's solution. "The time required for the calibration of NetLine/Plan significantly depends on the number of O&Ds to be looked at and the desired forecast accuracy. If a global data set for a medium-sized or large airline has to be calibrated, it is advisable to spend around three to four months to produce high-quality forecasts. For individual case studies touching a small number of O&Ds only, the calibration time can be reduced to a as little as two weeks," says Jurisch.

It may only take as little as two weeks to calibrate QSI and Logit models to analyse a small number of QSI models.

"Discrete choice models that are typically used are very time consuming to calibrate. They are set up over months or years and then maintained. It is not necessary that they take so long, but all sorts of problems can arise and people are usually pretty cautious. Also, they are typically used in strategic decision-making (how should I change my route structure this year?) rather than tactical decision-making (how do I fix a disrupted schedule?), so taking a while to set them up usually is not a problem," says Boyd.

Antolini comments that "QSI models are typically easier to calibrate than Logit models because QSI points are additive. Logit calibration is much tougher because all of the service factors are lumped together into the log transformation. I would say a QSI model could be calibrated in one week's time, while a Logit model may require a month or more."

Prerequisites for accuracy

What is required to deliver accurate forecasts? "Our forecasts are generally quite close to actuals when there are not too many changes in the marketplace (competitive changes and fare changes). On average, they are probably within 5-10% of forecast," says Yap.

"Two things are required to deliver accurate forecasts: 1) Reliable, timely data on industry schedules and fares; and 2) A model that can translate the data into forecasts," comments Barlow. "Sabre's experience is that the Official Airline Guide or Schedule Reference Service provides reliable, timely data on industry flight schedules while the Air Traffic Publishing Company provides reliable, timely data on competing fares. It is important to ensure that the model include all relevant effects necessary to represent how passengers choose flights. Sabre's models includes factors such as: nonstop/connecting service; preferred times of the day and week; price elasticity, degree of preference for unrestricted fares; time sensitivity; and carrier preference,"

Jurisch continues. "The quality of the forecasts obviously relies on the quality of the input data. (This is sometimes referred to as the 'garbage-in-garbage-out principle'). For the calibration of the NetLine/Plan models, high quality passenger statistics from previous planning periods are required. Lufthansa Systems has used various input data from different sources to calibrate NetLine/Plan. The choice of the data source depends on the availability of the data and on the specific needs of the planning airline."

Antolini seems to favour QSI. "Accurate market sizes are the most important factor in producing accurate forecasts. Assuming you have an accurate market size, QSI and Logit can both deliver accurate forecasts. Again, this depends on proper calibration, which is much easier to achieve with a QSI model."

Flexibility

How flexible is the system? "Discrete choice models are quite flexible because they can model pretty much whatever you want. They can be inflexible in that small changes can lead to radically different predictions, and the predictions do not always make sense for users," says Boyd. "Sabre systems (AirFlite and AirMax) are flexible enough to consider all known scheduling and pricing variables available from industry schedule and fare data providers. In case other effects are needed, Sabre's systems can be adapted to include new variables as long as data on these variables are easily accessible. Beyond additional variables, Sabre's systems are calibrated by passenger type (for example, business/leisure) and passenger location (region, country, city) to capture differences in passenger behaviour (for example, leisure passengers are less time-sensitive and more price-sensitive than business passengers). The systems are flexible enough to add additional passenger segments if desired."

Jurisch analyses two different perspectives for the flexibility requirement. "A system user's perspective is that schedules can be edited interactively via the NetLine/Plan graphical user interface. On currently used standard hardware a single schedule scenario can typically be evaluated in about 20-30 seconds. This enables the user to investigate and analyse a large number of schedule scenarios interactively, and the model technology perspective is that the parameters of the QSI and Logit models within NetLine/Plan can be configured within a wide range. In this way, the models can be adjusted to the specific requirements of the airline."

Again, Antolini favours QSI regarding this issue. "QSI models are very flexible and are superior to Logit models in real world modelling primarily because of their flexibility. Most forecasts require some adjustment even after a model has been properly calibrated. Things like passenger and revenue share gaps vary by market and area of the world. Adjusting a QSI model to account for an empirical share gap is much easier than adjusting a Logit forecast, primarily because Logit's log transformation mixes all the factors together, making it harder to isolate the effect of each individual one. All other things being equal, Logit models demand a higher level of mathematical understanding on the part of the forecast analyst. Both models can deliver reliable results-it is just harder and requires more skill when using a Logit model." AC