Making optimum fleet-planning decisions is of vital importance to any airline. QSI tools in demand forecasting perform a vital task in aiding these decisions. This article analyses approaches to QSI, the importance of data and forecasting accuracy in QSI, and its utilisation the fleet planning process.

Using QSI tools in the fleet planning process

The importance of having an optimal fleet mix, an optimised schedule, and systems for optimising revenue management (RM) in place is well known across the airline industry. Passenger-demand forecasting models are a key component of these functions, since they forecast the number of passengers on any given route for a given day. This allows airlines to plan capacity accordingly. This is not a simple process, however.

One of the most important components of forecasting passenger demand is the quality service index (QSI). QSI is used as the key methodology in many passenger-demand forecasting systems. This article analyses what QSI is, how it is calculated, the parameters involved, its role in fleet planning and other areas, its accuracy, and any alternatives available.

QSI calculation

QSI is a commonly used and relatively straightforward market share technique, which was originally developed by the US Civil Aeronautics Board in the 1950s. QSI uses a series of parameters to explain travel behaviour on a given origin-destination (O&D) city-pair.

QSI models passenger buying and selection, and is used to rank the itineraries in any given O&D market by passenger preference. This gives each airline in that O&D market a market share figure. This is then applied to the total known passenger traffic in that market to forecast the number of passengers that each airline is likely to attract.

François Laburthe, director, operations research and innovation at Amadeus, explains, "QSI is a technical measure to see how competing airlines compare on any given route. The QSI figure shows a split of market share for each airline, and is then used for forecasting models of demand."

A simple example can be used to illustrate this. If passengers only choose an itinerary based on a preference for direct, non-stop flights, then the QSI value is very easy to calculate. If only two airlines compete on a given O&D route, and both airlines offer a mixture of non-stop and one-stop services, then the passenger's preference for non-stops means that the airline that offers more non-stop services than the other will have a higher market share. The QSI model will show that if the first airline increases the number of services on this route, it will not be sufficient to capture the greater market share as long as the number of non-stops offered remains less than the number offered by the second airline.

In reality many factors and variables affect passenger preference for a given itinerary. This varies from airline to airline and from market to market. In some markets, fare price might be more important than non-stop service. In others, departure time might be more important to the passenger. This can make QSI modelling extremely complex for large network airlines competing on a large number of routes, especially because many different passenger preference parameters can be involved in any given O&D market.

Jörg Pikolin, vice president, product management airline solutions at Lufthansa Systems, illustrates this. "Attributes of an itinerary that can be considered as QSI preference factors include: connection types (non-stop, one-stop); airline preference; return market quality; departure/arrival time preference; fare price; elapsed travel time; airport preference; airline alliance preference; and airline dominance preference." There could be several other passenger preference factors involved that are specific to a given O&D market, which can be included in QSI calculations.

This means that complex and sophisticated software systems are needed in order to calculate accurate QSI values, and therefore to provide accurate QSI-based demand forecasting. "QSI is typically calculated using a linear multiplicative equation that comprises many variables modelling passenger behaviour and choices," says Jeremy Million, solutions manager, scheduling and planning products at Sabre Airline Solutions. This multiplicative equation, or algorithm, often varies in complexity dependent on the airline customer. A short-haul airline with a small fleet would not need such a complex model as a large network carrier, operating globally.

Laburthe breaks down the process that occurs in this algorithm: "Each passenger preference characteristic is assigned a weight according to its importance: so, if the departure time is more important than the type of aircraft used, the departure time is assigned a higher weight value. This is done for all travel alternatives in one market, and each travel alternative obtains a QSI value. These QSI values are then summed. Finally, the relative QSI value for each travel alternative is obtained (all adding up to 1.0), to give the market share."

QSI approach

Lufthansa Systems, Sabre Airline Solutions, and Amadeus, three of the major airline IT systems providers, differ slightly in their approaches to providing QSI-based passenger-demand forecasting

Once QSI values are estbalished they are used in route and network schedule planning, fleet planning, and revenue management.

solutions.

Lufthansa Systems primarily customises its QSI solution offered to each customer. "The business model of the airline and the data available for the calibration are the most important factors in its QSI model," says Pikolin. "When regional or low-cost airlines look at the market, they focus on different challenges compared to a full-scale network carrier, so we will use different passenger preference attributes for those business models. If fully detailed data are available, we can estimate more attributes than if we only have highly aggregated input data. This could be 20 attributes or just two or three; it is defined by the business model of the customer and its data."

Although the mathematics behind the QSI algorithm remain the same for all customers, Lufthansa Systems is able to either customise exactly what it inputs into the system based on each individual customer, or offer a standard pre-configured data set. This means that Lufthansa Systems offers a highly customised solution for each airline customer, or a standard model with standard parameters.

Sabre takes a similar approach. "We offer both a standardised QSI solution and a more customisable one," says Million. A small, localised, short-haul carrier may not need a complex solution, since it is only competing on a limited number of O&D markets, with a limited number of competitors. A large, multi-faceted, network legacy carrier, however, may require an extremely complex QSI solution given the high number of O&D markets and competitors that need to be included. Sabre can provide QSI solutions for both these types of airlines, and everything in between.

Amadeus takes a different approach. Amadeus offers one global model, suitable for all customers. As one of the four major global distribution systems (GDS), Amadeus has access to a large amount of global O&D data, and this is reflected in its QSI offering. "By using one global model, patterns are revealed in the data, and give an excellent picture of passenger preference choices," says Laburthe. This one global model has an extremely complex algorithm underlying it, which has the ability to adapt to route and itinerary changes in any individual O&D market. This makes the Amadeus product suitable for all types of airlines, whether they are a small low-cost carrier (LCC), or a large network carrier.

QSI utilisation

QSI demand forecasting is used primarily in three different ways: in route/network and schedule planning; in fleet planning and assignment; and in RM.

First, QSI demand forecasting can be used in network and schedule planning. "QSI-based forecasting can be used to help an airline decide what destinations to fly to, or whether it will be adding new routes, or maintaining current routes," says Million. "QSI values, for example, may show a passenger preference for travel to a primary airport, such as London Heathrow, over a secondary airport like Gatwick or Luton." This means airlines can use QSI demand forecasting to plan their network according to where anticipated demand will be, and plan routes from there. "QSI helps to determine if a new route is needed, or to add a frequency to a current route, or both," continues Million.

Assuming sufficient historical data are available, seasonal fluctuations in demand should also be reflected in QSI-based demand forecasting. This will show changes in passenger travel preferences in the summer and winter seasons. Airlines can therefore change their schedule and/or network according to these seasonal fluctuations.

If the relevant data are available, QSI-based forecasting will also help in the flight-scheduling process. For example, QSI values may show that passengers prefer to travel early in the morning to some destinations, but later in the day to others. This will help scheduling analysts create the operating schedule to align it with demand, thereby hopefully giving it the highest revenue-earning potential. This will vary from market to market, and will depend on the airline's focus. Departure times may be important attributes to some airlines, but not to others. Departure times may be the most important factor in making an itinerary choice for airlines operating in business-

The differing levels of demand that QSI values predict on a route highlight the importance of commonality between members of an aircraft family. Fleet commonality, between types of A320 and 737NG families, means that larger and smaller types can be switched between routes on a network with minimal changes to crew scheduling.

centric markets. QSI values therefore can help airlines align their schedules with these preferences.

"A QSI-based view of demand helps not only with point-to-point scheduling decisions, but also on deciding connection possibilities," says Laburthe. QSI values can show an airline what the preferred connection options are for passengers in non-direct O&D markets. This further helps with scheduling, since flights with high numbers of connecting passengers can be scheduled to arrive close to the connecting departure flights. As this helps airlines align schedules with customer demand, they have a higher chance of optimising revenue.

Second, QSI-based demand forecasting can be used in fleet planning and aircraft assignment. This is carried out at least six months in advance, but often a lot earlier. QSI-based demand forecasting will tell an airline how many passengers to expect on any given flight on its network. If 160 passengers are predicted on a given flight, for example, assigning an A320 or 737-800 will be the best option. Alternatively, if 300 passengers are predicted, a widebody such as the A330 or 777 should be assigned. Every airline has a different fleet mix, however, and an exact match of demand against capacity is rarely possible.

Using these QSI-based demand values, however, will allow an airline to optimise its aircraft assignment decisions. "QSI models are used in long-term fleet assignment; anywhere from three years to six months prior to departure," says Pikolin. "This allows airlines to assign the right-sized aircraft for each flight, subject to fleet mix and operational constraints."

This means that QSI models can also be used in long-term fleet planning. If an airline plans to expand into several new markets in the future, QSI-based forecasting can show it the expected demand. If, for example, these new routes have an expected demand of 160-180 passengers per flight, this helps the airline choose the appropriate aircraft to use or acquire for the expansion; in this example, the A320 or 737 families.

This is of course subject to other constraints, such as financial or operational issues. These constraints aside, QSI-based forecasting helps airlines to better plan for the future and to have the optimal fleet mix for future schedules.

The third way in which QSI-based forecasting can be used is in RM. RM aims to extract the highest possible fare from each individual passenger so that revenue is maximised. This means that airlines try to achieve the optimal fare mix of passengers on any given flight. QSI-based demand forecasting gives not only the number of seats to sell on any given flight, but also details on the travel preferences of the passengers. This enables RM analysts to price accordingly and to target the correct passengers with the correct prices.

If the QSI-based demand forecast shows business-oriented attributes are preferred, for example, the RM team know to target a higher number of business passengers, and price their fares accordingly. "QSI considerations are incorporated in the Sabre RM tool when forecasting demand at the O&D level," says Million. "The attributes used are: elapsed time; time of day; and fare price."

RM considerations are taken into account when further optimisation of schedules takes place relatively close to the departure date of any given flight. "QSI forecasting can be used to further optimise fleet assignment close to the departure date, 45-60 days ahead of departure," says Million. "Some carriers are even more flexible than this, and make changes 14 days ahead of departure; although this is not the norm."

Passenger travel preferences and demand are constantly changing, so fleet assignment carried out so far in advance may not match the actual demand at time of departure. RM tools help to keep QSI systems updated to keep up with passenger preference changes, so forecast demand figures can, and do, change closer to the departure date. Initial forecasts, for example, may have predicted 160 passengers for a given flight, so an A320 was assigned. As departure neared, passenger preferences changed and now the RM team is showing 200 passengers are expected. This means, therefore, that to optimise revenue, the airline should assign a larger aircraft to the flight.

"This is where fleet commonality is very important. Once schedules are in place, aircraft and crew are assigned to each flight and this is difficult to change without other significant changes being required to other parts of the schedule," says Million. "Fleet commonality, such as between members of the A320 family or 737 family, means that larger or smaller aircraft can be switched to a flight to better match demand, with minimal or no changes to crew scheduling." This is because A320 flight crews are also able to fly the smaller A318 and A319, or larger A321 aircraft interchangeably. The same is true for 737 'classics,' 737NGs, and other aircraft types. If QSI-based forecasts, therefore, predict higher or lower demand for a particular flight, then airlines with these fleets can better match capacity to demand closer to the departure date.

Forecasting accuracy

Data accuracy and reliability are of prime importance when making QSI-based passenger-demand forecasts. This is because of the wide variety of functions that these forecasts are used for.

Route and network planning, fleet

QSI values will even give a weighting to show passenger preferences for particular airports. This is noticeable between primary, secondary and tertiary airports at major cities such as London, Paris and New York.

assignment and RM all represent significant added value to an airline if they can be done optimally. As QSI is one of the key components in the demand forecasts used for those functions, the QSI values must be accurate and reliable to be useful, otherwise incorrect forecasts will be made, resulting in sub-optimal or incorrect route planning, fleet planning and RM decisions. This can increase costs and create a loss in revenue.

"The value of QSI-based demand forecasting is subject to the 'garbage in-garbage out' principle of the raw data," says Million. "If inaccurate data is entered into the system, then the QSI values, and the subsequent demand forecasts will also be inaccurate." This means, therefore, that the historical data used to make forecasts must be accurate and reliable before QSI values are calculated.

Although data quality is important, the quantity of data used is also vital to the accuracy of the final QSI values calculated. A few days' worth of historical data are unlikely to give a true picture of passenger demand in any given O&D market, because daily fluctuations regularly occur. A large amount of historical data is therefore required to find the patterns of passenger demand, and to analyse the various travel preference factors. "The more data you give the QSI model, the better and more accurate it gets. The more data that can be used means a larger scale model is developed, and better demand forecasts can be made," says Laburthe.

There are various data sources available to the airline customers to use in their QSI-based forecasting models. Marketing information data (MIDT) is a major source of data, and is derived from travel-agency-based GDS tapes. "MIDT combines information from the four major GDSs. This shows all the tickets that are sold through travel agents, which means that airlines can see volumes of passenger traffic for each O&D market," says Laburthe.

MIDT provides a large amount of information, and to be useful to an airline, many months of historical data are required. Due to the high volume of information, and the sensitive nature of the data and its key value to help airlines manage their travel agency partner's performance, the cost of MIDT increases with the number of O&D markets that are included. The value of the data also rises, however.

Without accurate and reliable data, however, any QSI model will not provide useful passenger-demand forecasts. This means that many airlines have to factor in the purchase of MIDT data when budgeting to make passenger-demand forecasts. "Airlines need to purchase MIDT data to make the best use of QSI-based forecasting," says Laburthe. "You need a complete picture of the markets: this includes all bookings from MIDT, but also direct sales and so on. MIDT provides a comprehensive picture with a high level of detail."

MIDT is often regarded as being most suitable for large airlines, with large route networks. MIDT can be valuable, however, to smaller airlines as well, because it is available in different packages, which have varying prices, to cater to particular market segments. Amadeus, for example, works with a number of smaller airlines to provide them with data that fulfil their business needs.

MIDT is not an absolute requirement for airlines, however, and there are other data sources available. "Airlines do not need MIDT to make use of a QSI-based forecasting system, but some form of market size data is necessary to perform a forecast and assign traffic to a flight or itinerary," says Million.

Pikolin agrees: "MIDT is very expensive, and it might not be worth it for small airlines, with a small route network. Alternative data sources could be used, such as OAG, so that these airlines use data that is most relevant to them."

Point-to-point markets are also easier to forecast than one- or two-stop O&D markets, since there are no intermediate stops. One- or two-stop O&D markets have many different possible combinations of itineraries available to a passenger, and therefore demand forecasts for these markets are harder to create. Small carriers serving a small number of point-to-point O&D markets would therefore not necessarily require MIDT for accurate demand forecasts.

For the major carriers, however, MIDT is certainly required to give the best QSI-based demand forecasts. This is due to the large number of O&D markets they operate in, which incorporate short- and long-haul flights, with many direct, one- and two-stop itineraries available.

The MIDT data must be combined with an airline's own sales figures to give it the best picture possible of each O&D market in which it operates. This is because an ever greater percentage of sales are made from direct channels, such as an airline's website. Without adding these data, it is difficult for an airline to obtain the most accurate picture of any O&D market. This adds to the complexity of any QSI-based forecasting model.

"The Amadeus Total Demand product, by airconomy, extends the use of traditional MIDT data to include data from all sales channels," says Laburthe. "Total Demand provides the most precise demand data for any city-pair in the world, and is based on advanced computational intelligence to give a global and 'gap-free' perspective on passenger demand."

Sabre offers a similar product, Global Demand data, which can be used to

QSI values will try to include a weighting for passenger comfort and levels of on-board service, although this is subjective.

forecast demand in any O&D market, globally. It is MIDT-based, since Sabre is one of the world's GDSs, and uses data from several other data sources to make up for gaps in its own data. Gaps can be caused by airlines not reporting data in certain parts of the world, but in particular, gaps can arise from an airline's own direct sales channels. Some LCCs do not use any GDS system to make bookings and are therefore not included in MIDT data. Not including these data in a demand forecasting system could present issues for other airlines in these relevant markets, because they will not have the full picture of the competition in the market. This could lead them to make incorrect decisions in terms of fleet planning, scheduling or RM.

"Global Demand data is MIDT-based, but involves the collection of data from all available sources, including airports, governments, schedules, and even screen scraping," says Million. "We use anything we can find to give our customers a better representation of the overall market through Global Demand data."

Considering the financial and operational implications of inaccurate QSI-based forecasts, the forecasts made need to be extremely accurate. Given the very large amount of data used in these forecasts, it is difficult to achieve 100% accuracy. "We [Sabre] always aim for the best accuracy possible, but keeping in mind there will always be some level of error," says Million. "Accuracy is determined at multiple levels, but at the highest level we aim for an error level of less than 4%."

As for Amadeus, Laburthe says: "We have compared our forecasts with the actual resulting passenger figures for airports, and the data error is usually in the range of 2%." This means airlines can make sound fleet assignment and scheduling decisions with such accurate QSI-based forecasts.

Pikolin illustrates how accuracy levels can change dependent on how far in advance the QSI-based forecasts are made. "Regarding forecasting accuracy, we usually measure this in comparing our model forecast to the historical input values. If we work with a very high accuracy, the model becomes inflexible and less able to forecast effects of schedule changes, where with higher flexibility the forecasting error rises," says Pikolin. "Therefore, for long-term forecasts we usually work with a more flexible calibration while for short-term forecasting we try to keep the forecasts more tight to the actual values. This means it is difficult to give true accuracy levels, since it depends on individual circumstances."

QSI systems must be updated regularly to include changes in the O&D markets, and changes in passenger travel preferences to maintain these high accuracy levels. "Data should be reviewed and updated every year and we recommend reviewing calibration twice a year due to the different preferences by season (summer versus winter)," says Million.

Pikolin echoes this. "QSI systems should be revisited about twice a year to update what travel preferences have changed since the last calibration. This depends on each individual customer, but many airlines find it extremely useful to update their systems regularly."

Alternatives

There are few alternatives to QSI-based passenger-demand forecasting. This is because to estimate demand for an airline in any given O&D market, its market share must be known. QSI provides a method of calculating market share, from which passenger-demand forecasts are extrapolated. Logit-based forecasting is often considered an alternative to QSI. Logit, however, is an alternate way of calculating the market share for an airline in any given O&D market and is presented as a percentage, rather than a value between 0 and 1, as QSI is presented. This means that Logit requires the same type of data to produce similar results to QSI. The difference is in the method of calculation.

"A significant weakness of demand forecasting is the lack of alternatives to QSI," says Pikolin. "This heightens the importance of the accuracy and reliability of QSI-based forecasting."

Laburthe reinforces this. "QSI is invaluable to passenger-demand forecasting systems. We are extremely satisfied with data quality and accuracy from our QSI models and our customers trust in our confidence in the data." QSI, therefore, will continue to provide the basis for many passenger-demand forecasting systems for years to come. AC