Practice Article

Did LCCs save airline revenue management?

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ABSTRACT The growth of low-cost carriers (LCCs) and their simplified fare structures highlighted the weaknesses of traditional airline revenue management (RM) forecasting and optimization. The LCC pricing revolution caused RM systems to falter and threatened decades of scientific research and RM system investment by airlines. At the same time, it provided a much-needed impetus for new RM research into improved forecasting and optimization models, laying the foundation for the next generation of airline RM systems.

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Low-cost carriers (LCCs) have changed the global airline industry, for better and worse. For consumers, LCCs expanded travel options to include basic air transportation at previously unheard-of low fares. For legacy airlines, the new competition from LCCs not only forced them to respond with comparable pricing to protect market share, it also led to unprecedented cost cutting. Arguably, LCCs provided the impetus for the most dramatic restructuring of the airline business since the start of deregulation in the United States in 1978, leading to tremendous improvements in employee and aircraft productivity for successful airlines, bankruptcies and/or liquidation for others.

But, did LCCs actually save airline revenue management (RM)? I propose that LCCs also provided the much-needed impetus for several

recent advancements in RM modeling and system development. We begin with a review of the evolution of airline RM systems, followed by a brief discussion of how LCC pricing strategies exacerbated the fundamental weaknesses of traditional RM models and systems. These weaknesses first caused airline RM systems to falter in the early 2000s, but then led to a renewed focus on research and development of new forecasting, optimization and estimation methods.

EVOLUTION OF AIRLINE RM: THE GLORY DAYS

The first airline RM systems, developed in the early 1980s, were designed to collect and store data extracts from computer reservations

systems. Some systems offered additional monitoring capabilities, comparing actual flight bookings to an expected or 'threshold' booking curve for a future flight and providing RM analysts with more guidance. By the late 1980s, airlines and RM system vendors began to develop and implement RM systems that made explicit use of mathematical forecasting and optimization models to calculate specific booking limits for each fare class for each future flight leg departure.

This 'third generation' of airline RM systems was credited with revenue gains of 4–6 per cent (Belobaba, 1989; Smith *et al*, 1992) from the use of mathematical models for overbooking and fare class mix on a flight leg basis. By the mid-1990s, more advanced airlines began to move toward the fourth generation of RM systems – network optimization or 'origin-destination (O-D) control'. Network RM allowed airlines to manage seat inventory according to the revenue value of each passenger's origin-destination itinerary, not simply according to the fare class requested on a single flight leg. Belobaba (2002) describes the various forms of O-D control and their benefits, estimated to be an incremental 1–2 per cent in network revenue gains over third generation leg-based RM systems.

Traditional RM systems were designed for the differentiated (restricted) fare structures of the 1980s and 1990s. Their forecasting and optimization models assumed independent demands for each fare class (or for each itinerary/class in network RM systems), given that restrictions prevented much diversion of demand between fare products. This assumption of independent demands for each fare product was never completely correct, and it became even more suspect with changing fare structures.

THE AIRLINE REVENUE 'PERFECT STORM'

The legacy airline pricing model that allowed traditional RM systems to function so well started to unravel around 2000. Rapid growth

of LCCs increased the number of price and itinerary options available to consumers, and LCC marketing strategies emphasized their less restricted or 'simplified' fare structures. New internet distribution channels gave more consumers more information than ever before about alternative fare options. Passengers became much less willing to pay 5, 8 or even 10 times the lowest available fare for travel on the same flight in the same economy class seat. At the same time, severe cost cutting by legacy carriers led to service quality cutbacks that all but eliminated consumers' perceptions that legacy carriers offer a better product.

LCCs led a pricing revolution toward 'simplified' fare structures that most airlines followed. Fare simplification involved the removal of segmentation restrictions on lower fares, most typically round-trip purchase and minimum stay requirements. Legacy carriers were effectively forced to match the LCC fare levels and to simplify their own fare structures in order to remain competitive. Although welcomed by consumers, simplified fares took from the airlines their most effective way of segmenting business and leisure demand.

This widespread shift to simplified fare structures caught RM systems and users by surprise, as existing forecasting models were not able to deal with the resulting changes in passenger choice behavior. As more consumers take advantage of the lowest (now less restricted) fares, fewer bookings are recorded by the RM historical database in the higher fare classes. The actual demand by consumers willing to pay the higher fares is then under-forecasted for future flights, allowing more seats to be sold at lower fares. This cycle of diversion is referred to as 'spiral-down' in RM systems and, left unchecked, results in inadequate seat protection for higher fares, too many bookings at lower fares and substantial revenue losses for the airline.

The ineffectiveness of RM systems in the early 2000s led to precipitous declines in yields and historically high record load factors – traditional RM systems were allowing

more and bookings at the lowest fares, while revenues plummeted. Airline RM departments tried to contain the damage with manual overrides of the recommendations of their existing RM systems, and we started hearing about a return to 'rule-based' RM. After several decades of scientific research and model development, airline RM seemed destined to return to the early 1980s when user judgment was the standard of RM practice.

AIRLINE RM: THE NEXT GENERATION

Having spent huge resources on developing their third and fourth generation RM systems, airlines realized that substantial changes to the forecasting and optimization components would be required if their systems were to be saved. The focus of much recent RM research has, therefore, been on the development of new models for less-restricted and even completely unrestricted fare structures. The goal was to find models that can function in a wide range of current and future competitive fare environments, by explicitly recognizing that the demand for different fare products is not independent. This renewed focus on RM research has begun to pay off, with new methods for demand forecasting, inventory optimization and estimation of passenger willingness-to-pay (WTP).

'Q-forecasting' (Belobaba and Hopperstad, 2004) and 'hybrid forecasting' (Boyd and Kallesen, 2004) are examples of new forecasting approaches that incorporate the concepts of WTP and sell-up. For fully undifferentiated fares, Q-forecasting forecasts the maximum potential demand for the lowest fare, then uses estimates of WTP to forecast demand for higher fare classes conditional upon closure of each lower class. Hybrid forecasting generates separate demand forecasts for price- and product-oriented demand, and is appropriate for fare structures with at least some segmentation restrictions. Traditional RM forecasters can be used to estimate product-oriented

demand, whereas Q-forecasting can be applied to forecast price-oriented demand.

Generating forecasts of demand by WTP, however, is not enough to ensure that revenues will be maximized, particularly on flights with more capacity than demand. RM optimizers also needed to be modified to incorporate information about the propensity of passengers to buy down in a given fare structure. The concepts of 'fare adjustment' and marginal revenue optimization (Fiig *et al.*, 2010) allow airlines to apply separate controls to restricted and unrestricted fare structures on the same flight leg. This methodology reduces the fare value fed to the seat allocation optimizer for less restricted fare structures with greater risk of revenue loss due to buy-down, closing lower fare classes earlier in an attempt to encourage sell-up. This fare adjustment theory has been extended to a variety of RM systems and can be applied to almost any fare structure.

These new forecasting and optimization models require estimates of passengers' WTP – in the form of sell-up probabilities, price elasticities or 'FRAT5' curves. The estimation of these inputs has proven to be a major research challenge. The sparseness and volatility of actual sell-up behavior in historical booking data makes the detailed estimation of specific sell-up probabilities by O-D market, day of week and time of day very difficult if not statistically impossible. Passenger Origin Destination Simulator (PODS) Consortium research has led to the development of several estimation methods, but even in a simplified simulation environment, aggregation of sell-up estimates across markets is essential, as demonstrated by Boyer (2010).

These new developments in RM forecasting and optimization were born out of the necessity to adapt traditional RM systems that faltered under the less restricted fare structures introduced by LCCs. So did LCCs save airline RM? If providing the impetus for researchers, system vendors and airlines themselves to address the shortcomings of traditional RM models encouraged the long overdue development of new forecasting and optimization

models for the next generation of RM systems, then the answer is yes.

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