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PRACTICE ARTICLE

An approach to adaptive robust revenue management with continuous demand management in a COVID-19 era

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Abstract
The novel coronavirus pandemic has had a seismic impact on the travel industry. With a steep drop in customer demand and the inability of airlines to forecast demand for flights with any degree of accuracy, this paper proposes an alternative approach to revenue management that monitors key revenue management metrics and take corrective action with demand and supply levers to make the revenue plan happen. In a COVID-19 era, in the absence of reliable demand forecasts, this operationally driven robust revenue management approach is a viable alternative to manage seat inventory than traditional methods.

Keywords COVID-19 · Pandemic · Robust revenue management · Demand forecast accuracy · Revenue management metrics · Demand levers · Supply levers

Background

Research into Robust Revenue Management in the academic community was influenced by the validity of the assumptions made by revenue management models to determine optimal inventory controls (Queyranne and Ball 2006; Birbil et al. 2009; Perakis and Roels 2010; Rusmevichientong and Topaloglu 2012; Liang et al. 2017; Gönsch 2017). A revenue management approach without demand forecasts and optimization using an adaptive model that relies on historical data has also been proposed (van Ryzin and McGill 2000). Common revenue management modeling assumptions that came under scrutiny were the functional form of the distribution of demand, deterministic assumption of market fare values despite its uncertainty and accuracy of the consumer choice model estimates of the logit coefficients after schedule changes. The product of traditional robust revenue management techniques is to produce stable, if often conservative, inventory control recommendations. Simulation experiments based on underlying assumptions for the input variables will indicate that revenue management models will always outperform robust revenue management models and hence traditional robust revenue management techniques have never been a priority for airlines and revenue management software providers.

The need for a more "Adaptive" robust revenue management approach that relies less on stable historical controls but adapts using up-to-the-minute monitoring of key performance indicators is greater as the world continues to live with the novel coronavirus pandemic (COVID-19). Historical data has become much less predictive of future performance than it was in a more stable time. The mandated shut down of non-essential businesses in March and April of 2020 to contain the COVID-19 virus also saw significant capacity reductions from airlines when leisure demand evaporated in domestic markets. International flights were almost completely shut down in March and April 2020. These capacity reductions even dwarf the fallout from the terrorist attacks from September 11, 2001 and IATA predicts that cumulative airline losses could exceed 250 billion dollars (RT 2020). For example, United Airlines has cut capacity by 80% (Witkowski 2020). It is unlikely that travel will rebound to 2019 levels until an effective vaccine can be produced at scale. Even after a vaccine, recovery of the airline industry could take 2–3 years. While countries worldwide deal with containing the spread of the virus with social distancing and shelter-in-place orders from state, city, and local authorities, the virus is still in our midst. As flights and local businesses start re-opening in May, it will be a slow process, where caution needs to be exercised. We live in unprecedented time due to the volatile nature and unpredictability

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of future outbreaks with infections as observed with new cases. In the current environment, traditional planning and optimization models will not work due to the uncertainty of the business environment, and historical data has limited value at best. Robust Adaptive Revenue Management with continuous demand management is an approach to manage discount allocations during this period of high uncertainty and volatility.

The dynamics of a competitive landscape with transparency to selling fares and schedules requires airlines to adopt sound robust revenue management tools and techniques to ensure price competitiveness in the marketplace, minimize revenue dilution and protect market share. Robust Adaptive Revenue Management is not a specific technique but a combination of various techniques and related business processes that airlines should adopt into their current revenue management processes to maintain their competitive edge.

Dealing with and mastering uncertainty

Dealing with demand uncertainty is one of the key cornerstones of revenue management. Revenue management systems typically model demand uncertainty by determining the profile of the demand curve—the distribution, first and second moments—and use this information in leg and network optimization models. A measure of the uncertainty of demand is the forecast error associated with the demand forecast. Higher uncertainty in demand leads to less aggressive inventory controls which lead to lower revenues than can be realized if demand uncertainty is lower.

Everyone strives to create an accurate forecast and achieve success to varying levels. Based on the premise that the *demand forecast is always wrong*, Robust Adaptive Revenue Management is a framework to master uncertainty by adapting to the environment, anticipating potential problems based on an early warning and then taking proactive corrective actions on future flight departures before the problem becomes widespread.

Steady-state operations and continuous demand management

Revenue management serves a central role in an organization. For a typical airline, there are two revenue management functions—strategic (long term) and tactical (short term). Tactical revenue management focuses on the goal of maximizing revenue with a given schedule and fare structure. Strategic revenue management focuses on planning for the long term. Long-term revenue management planning must consider the marketing plan encompassing flight schedules, fares, group and off-tariff sales practices, distribution methods, passenger handling policies, frequent flyer program, and advertising. Because so many functions are involved, long-term planning must be conducted at the corporate level.

For example, the "displacement rate" measured as the ratio of spill-to-date (passengers turned away because the booking class was closed) to the unconstrained-demand-to-date by booking class is an important measure to track on a pre-departure basis. When the measure is not increasing along the booking class hierarchy, it is obvious that there is a problem and serves as an early warning signal to take corrective action.

Key Performance Indicators associated with revenue management, like yield, revenue/ask, spoilage, market share, oversales, forecast error, and spill rates should be tracked and monitored across organizational silos, given its relevance to the key stake holders in an airline. This end-to-end transparency horizontally (across organizational boundaries) and vertically (within an organizational hierarchy) should be leveraged to enable zero latency in decision making. The figure below illustrates the various functions within the airline that can benefit from an effective revenue management process. Business process integration across these functional areas is required for effective decision making. This entails the optimal usage of revenue management data (both inputs and derived outputs) for effective decision making across the major functional areas in airline planning and operations (Fig. 1).

As is most often the case, forecast accuracy is blamed for poor corporate performance. If forecasts were perfect, achieving the target performance measures would be a non-issue. The typical symptoms observed are that forecasts may be accurate at a macro level (e.g., market), but not accurate at the itinerary class level, where seat inventory is controlled and consumed. Frequently, situations may arise when too many discount seats have been sold resulting in higher valued passengers being spilled. As a direct consequence of these issues, there tends to be finger pointing between sales and revenue management and operations when plans are not met. In a COVID-19 or post COVID-19 world, significant volatility in demand forecasts is anticipated, making the planning process in revenue management and the resultant inventory controls far from optimal and ensuring even more finger pointing. What the functional silos are failing to recognize is that the business environment is becoming too dynamic to just rely on accurate forecasts to drive performance. Furthermore, low-cost carriers (LCC) competition is increasing, which makes accurate forecasting even more challenging.

Leaving traditional revenue management processes aside for a moment, ultimately what is most important for an airline is to "make the plan happen." The "Plan" is essentially meeting revenue and market share targets for the current

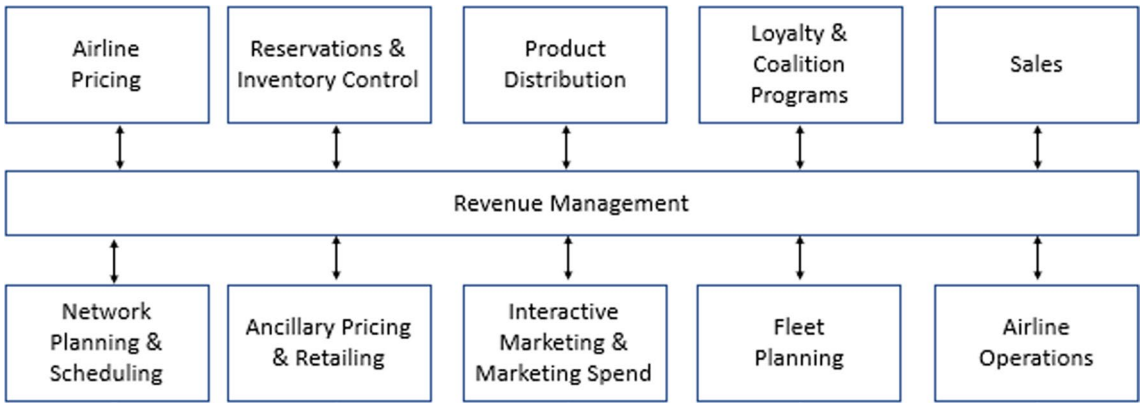

Fig. 1 Impact of revenue management across airline functions

Fig. 2 Forecast accuracy versus proactive management

period, achieve target customer service levels to protect future revenues and achieve cost targets. A paradigm shift is required to manage demand continuously to effectively manage the business even if the forecasts are not accurate. *Continuous demand management* requires active monitoring of key performance indicators and proactively review alerts to take the pertinent corrective actions to ensure that the plan can be achieved. This rapid *sense and respond* capability of continuous demand management addresses demand variability positively to deliver on targets outlined in the plan (Fig. 2).

Based on the fundamental recognition that variability in the competitive environment is too high to forecast accurately, the question is: *how can revenue management performance measures be used pro-actively to make the plan happen consistently in spite of high variability in demand?* The answer is to embrace the paradigm of *continuous demand management* which calls for putting processes and plans in place that account for variability and then proactively using all the business levers available to respond to make that plan happen. This is accomplished by balancing current and future goals as well as revenue and costs by proactively using all the available business levers to take corrective action.

The core objective of this approach is not to maximize profit, but to minimize maximum regret. In other words, what are the actions that can be taken to minimize missteps, even if some revenue is left on the table.

To address variability, *latency* should be overcome to ensure proactive management. Latency results because of slow propagation of information resulting in excessive cycle times for decision making.

Central to the orchestration of continuous demand management based on alerts generated from revenue management performance measures is event management. The management of events serves as a central nervous system. This requires the definition of revenue management KPI's at distinct levels of aggregation, frequency of monitoring (by the minute, hourly, daily, weekly, etc.) and possible recourse for a corrective action by invoking a demand lever or a supply lever. The figure below illustrates how events can be established and orchestrated for proactive decision making.

Examples of demand levers are pricing actions, promotions, sales incentives, and overrides, etc. Examples of supply levers are capacity changes, change frequency on markets served, enter new markets, etc. Typically, the effects of invoking a demand lever can be felt immediately while supply levers are less agile, and the impacts will only be realized after a few weeks. The figure below illustrates an event, the root cause analysis framework to understand what caused the deviation from the plan and the business lever (supply or demand) that should be invoked to take corrective action.

Figure 4 above illustrates the root cause analysis framework for a single KPI (system revenue). Note that the activation of the business lever may lie in different organizations such as pricing, revenue management, sales, capacity

planning. A similar decision tree will be required for all KPI's that need to be monitored to ensure consistency in decision making.

With the significant reductions in capacity, airlines are focused on developing future schedules using a clean sheet scheduling approach that does not rely on past schedules. This gives airlines flexibility with timing, routing, frequency, and capacity allocation. Clean sheet scheduling further diminishes the value of historical demand data. The approach outlined in Figs. 3 and 4 is vastly different from the traditional revenue management analyst workflow of reviewing critical flights and markets to take corrective action. Instead of the traditional bottom-up approach of reviewing individual critical flights and markets in the problem window, a top-down approach is recommended to take corrective action since it is unlikely that historical demand for individual flights and markets will have any bearings on the future state in a Covid-19 and post Covid-19 world.

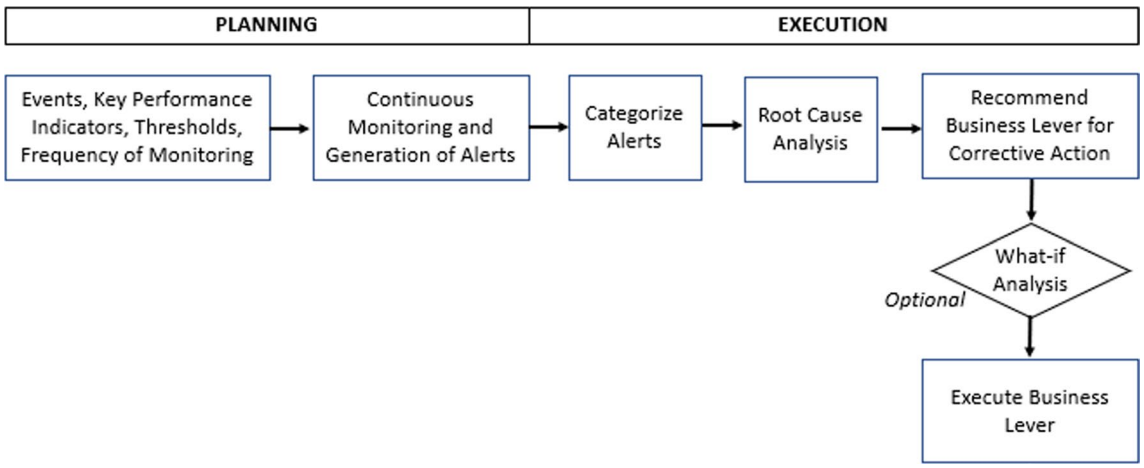

Fig. 3 Events and alerts resolution

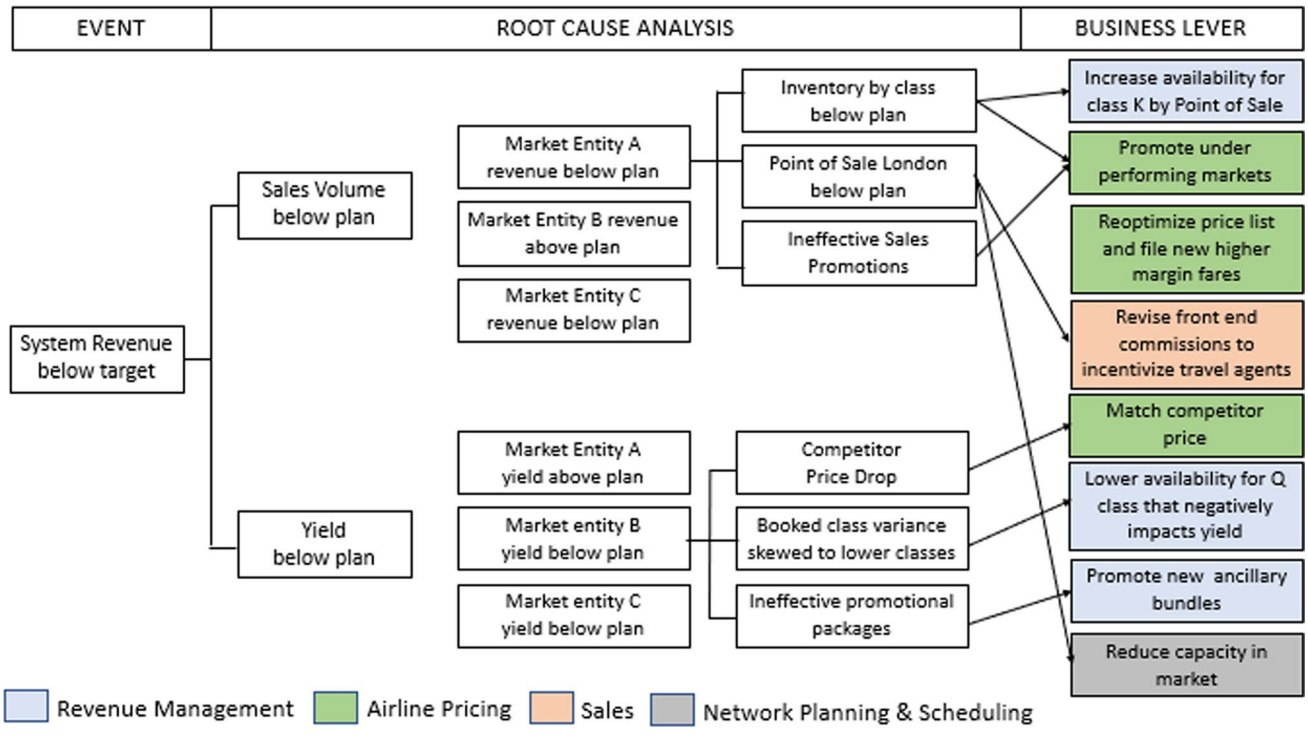

Fig. 4 Alerts, root cause analysis, and resolution

Conclusions

To get the most out of a revenue management program in a COVID-19 era requires the implementation of robust adaptive techniques based on the assumption that historical demand patterns cannot predict what lies ahead. The continuous monitoring of pre-departure key performance indicators to provide continuous feedback and take corrective actions in real-time provides a framework for implementing this new approach. Ultimately, in steady state, revenue management can play a key role to "make the Plan happen" with the process of continuous demand management during this period of uncertainty. Implementation of revenue management awareness across the organization is critical to ensure transparency across the organization and leverage key revenue management-related performance indicators to ensure that revenue plans are met by enabling zero latency in decision making.

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