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## Research Article

# Milestones in the application of analytical pricing and revenue management

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**Robert G. Cross, Jon A. Higbie and Zachary N. Cross**

*Revenue Analytics, Inc., Atlanta, GA 30339, USA.*

Robert G. Cross is the Chairman and CEO of Revenue Analytics. He guides Revenue Analytics' strategic vision. Labeled the 'Guru of Revenue Management' by *The Wall Street Journal*, he authored *The New York Times Business Best Seller, Revenue Management: Hard Core Tactics for Market Domination* (Broadway Books 1997). He served as Distinguished Executive-in-Residence at the Terry College of Business at the University of Georgia. He holds a JD (cum laude) and a BA in Chemistry from Texas Tech University.

Jon A. Higbie is Senior Vice President and Chief Scientist of Revenue Analytics. He heads one of the world's foremost groups of operations research scientists helping leading companies in the application of sophisticated pricing, forecasting and revenue management techniques. Before joining Revenue Analytics, he served as Chief Scientist for Revenue Management at JDA Software, Inc. He also served on the faculty of the College of Management at Georgia Tech. He holds a PhD in Management Science and Information Technology from The University of Georgia, and a BA in Physics from Wittenberg University.

Zachary N. Cross serves as Revenue Analytics' Senior Vice President, Revenue Management Strategy. He leads client engagements and a team of professionals at Revenue Analytics focused on client strategy and business process issues. His organization helps clients measure price responsiveness, improve pricing and discounting strategies and execution processes, and develop performance measurement tools. He joined the company from Revenue Technologies, a leading provider of pricing and Revenue Management software solutions. He holds a BBA with a double major in Marketing and Entrepreneurship from the University of Miami.

**Correspondence:** Robert G. Cross, Revenue Analytics, Inc, 3100 Cumberland Blvd, Suite 1000, Atlanta GA 30339, USA

**ABSTRACT** This article identifies major milestones in the science of Pricing and Revenue Management. It starts with the first successes in travel and transportation, and it follows the progression of the discipline in those realms. It explores breakthroughs as the concepts evolved beyond airlines and other industries with perishable products. It examines the impact on traditional Pricing and Revenue Management thinking, as the adaptation of these concepts to diverse industries has necessitated strategic and tactical innovations to optimally manage discount, promotions, bulk and negotiated deals as well as customer retention. Finally, it suggests future milestones as the science continues to grow and evolve.

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## INTRODUCTION

It started as a desperate strategy for struggling airlines faced with the chaos of deregulation.

They had only hoped to stem the losses. Instead, they inadvertently created a revolutionary way for all companies to boost revenue

and profits by using data and analytics to predict customer behavior and optimize the price and availability of products.

It is no exaggeration to say that over the past few decades, sophisticated Pricing and Revenue Management techniques have added tens of billions of dollars to the net profits of hundreds of firms. The remarkable thing about these profit improvements is that they typically come from existing products and often from existing sets of customers.

The essence of this discipline is in understanding customers' perception of product value and accurately aligning product prices, placement and availability with each customer segment.

Before the introduction of this discipline, product managers had traditionally focused on the cost of the product, its physical attributes (size, features and functions) and the margins they seek from the product. Product positioning vis-à-vis the company's other offerings and competitive offerings also played a role. However, this mostly internal focus created a disparity between the product manager's perception of the product's value and customers' perception.

The positive gap between a customer's value perception and a producer's value perception is money left on the table. Economists call this 'consumer surplus'. A negative gap is 'producer surplus' (Mankiw, 2009). The lost profit opportunity from these gaps has been understood, but capturing the lost opportunity was generally not considered a matter of survival until airline deregulation. At that point, new competitors sprung up overnight with costs that were one half those of existing airlines, putting immense pressure on incumbents.

The humble beginnings of Revenue Management were simply a means of self-preservation ... a new twist on an old game of supply and demand management in which revolutionary thinking and rapidly evolving computer technology played a critical role (Jenkins, ed., 1995).

The concepts spread relentlessly to other industries where competitive pressures and the need for profitable growth spurred innovative

thinking. The discipline has grown significantly beyond its original concept as a means of controlling inventory and is now considered by many firms as an indispensable part of their marketing and operating strategies.

We wish to chronicle and bring to life some of the most significant actions by companies and individuals in the evolution of this discipline. We seek to explore the impetus for its adoption in new industries and the factors that contributed to its widespread success and diffusion throughout numerous industries.

We have defined a 'milestone' as a significant landmark along the journey that was not only a successful and public 'first', but which has also spawned followers. We hope that the identification and examination of these milestones will assist the journey of others.

## **IN THE BEGINNING – AMERICAN AIRLINES**

Perhaps the first recognized innovation in the development of Revenue Management was the experimental offering of differentiated fare products for essentially the same seats during the early 1970s. In 1972, British Overseas Airways Corporation (now British Airways) offered capacity controlled 'Earlybird' discounts to stimulate demand for seats that would otherwise fly empty (McGill and van Ryzin, 1999). Nevertheless, the most visible milestone in Revenue Management at the beginning of this discipline occurred at American Airlines.

By the mid-1970s, the Civil Aeronautics Board, which set airfares for US scheduled airlines, introduced the concept of 'public charters' that enabled charter airlines to sell seats on a quasi-scheduled basis for fares far less than the cost-plus fares offered by the scheduled airlines (Jenkins, ed., 1995).

In 1976, Bob Crandall, then Senior Vice President of Marketing for American, called an emergency brainstorming session to examine how American might lower its costs to compete. Late at night as they were discussing the situation, they re-framed the question.



It dawned on the team that American's planes were flying only half full. They were carrying millions of empty seats per year. That meant that they were already producing some seats at a cost approaching zero. In the wee hours of the morning, the team realized that they had a *revenue* problem that was more critical than their *cost* problem (Cross, 1997).

From that point forward, the marketing team focused their efforts on generating revenue from excess capacity. Their initial solution, introduced in 1977, was called 'Super Saver Fares', which were capacity-controlled and advance-purchase restricted. They started with 30 per cent of the seats on each flight allocated to the Super Saver Fares; however, they quickly realized that fluctuating demand patterns by route, time-of-day and day-of-week required a different mix of discount seats.

Large databases were constructed and computer systems were developed to forecast and monitor passenger demand. Skilled analysts were trained to oversee the system to account for variances and allocate the discount seats with greater precision. Bob Crandall is credited with giving this integrated set of people, process and systems a name. He called it 'Yield Management'. The discipline generated hundreds of millions of dollars in additional revenue, and it completely defused the competitive threat from public charters. (Jenkins, ed., 1995).

American continued to invest in Yield Management's forecasting, inventory control and overbooking capabilities over the years. However, by the early 1980s, the combination of a mild recession and new competition spawned by airline deregulation posed an additional threat. Low-cost, low-fare airlines like PeoplExpress were growing rapidly because of their ability to charge even less than American's Super Saver fares. Every month, PeoplExpress announced spectacular traffic gains. They were the fastest company ever to grow to US\$1 billion in revenue.

By then, Bob Crandall was American's President. He recognized the potential of

Yield Management as a competitive weapon. American was investing millions in the next generation capability, which they would call DINAMO (Dynamic Inventory Optimization and Maintenance Optimizer). On 17 January 1985, American announced Ultimate Super Saver Fares that were at even lower prices than PeoplExpress and were non-refundable in addition to being advance-purchase restricted and capacity controlled. The Yield Management system carefully targeted those discounts to only those situations where they had 'surplus seats' that they could use to out-manoeuvre the competition. The system and analysts engaged in continual re-evaluation of the placement of the discounts to maximize their use. Over the next year, American's revenue increased 14.5 per cent and its profits were up 47.8 per cent. PeoplExpress was gone the following year. Yield Management was an undeniable success (Cross, 1997).

While American's triumph was the most visible, other airlines were also adopting Yield Management with notable effect. Delta Air Lines' application of Yield Management in 1984 generated \$300 million in annual revenue and was cited by the *Wall Street Journal* as a major factor in its reversing its losses from the previous year (Koten, 1984). United Airlines was the first to develop and implement an Origin and Destination-based system that controlled inventory based on passenger flows (*Aviation Daily*, 1997). Contrary to conventional thinking, low-cost carriers such as Southwest Airlines were also early adopters (Scorecard, 1994).

British Airways, KLM Royal Dutch Airways and Lufthansa were among the first in Europe to leverage Yield Management principles to exploit opportunities created by the liberalization of air travel in Europe (Jenkins, ed., 1995). Today the practice is an integral part of the commercial operations for virtually all airlines globally. Bob Crandall, ultimately Chairman and CEO of American, famously said, 'Yield Management is the single most important technical development in transportation

management since we entered the era of airline deregulation ... . We estimate that Yield Management has generated \$1.4 billion in incremental revenue in the last three years alone' (Smith *et al*, 1992). The success at American was the progenitor for all that followed.

## FIRST ADOPTION BEYOND THE AIRLINES – MARRIOTT INTERNATIONAL

J.W. 'Bill' Marriott, Jr heard about Yield Management directly from Bob Crandall at a chance meeting in the mid-1980s. Marriott International had many of the same issues that airlines did: perishable inventory, customers booking in advance, lower-cost competition, and wide swings with regard to balancing supply and demand.

The application of the principles, however, was not as straightforward as a high-level view might suggest. Most significantly, while airlines could have central staffs administer Yield Management, individual General Managers at each hotel were responsible for P&L at the hotel and accordingly also had rate and inventory responsibility. This difference in the business model called for a decentralized approach, with regional and global support and oversight (Cross *et al*, 2009).

Bill Marriott sought to incorporate Yield Management into the marketing strategy of all Marriott hotels. Since 'yield' is an airline term, Marriott and others adopting the practice called the practice Revenue Management (Cross, 1997). The company created a Revenue Management organization and invested in automated Revenue Management systems that would provide daily forecasts of demand and make inventory recommendations for each of its 160 000 rooms at its Marriott, Courtyard and Residence Inn brands (Marriott and Cross, 2000). They also created 'fenced rate' logic similar to airlines, which would allow them to offer targeted discounts to price-sensitive market segments based on demand (Hanks *et al*, 1992).

To address the additional complexity created by variable lengths-of-stay, Marriott's Demand Forecast System was built to forecast guest booking patterns and optimize room availability by price and length of stay. By the mid-1990s, Marriott's successful execution of Revenue Management was adding between \$150 million and \$200 million in annual revenue (Marriott and Cross, 2000).

Dave Roberts, Marriott's Senior Vice President of Global Revenue Management, acknowledges that Revenue Management is now inextricably linked with market strategy (Cross *et al*, 2009).

Marriott's development of a next-generation Revenue Management capability called One Yield was granted the 2005 Grand CIO Magazine Enterprise Value Award in recognition of using technology to improve its bottom line. In *Competing on Analytics*, Davenport and Harris (2007) recognize Marriott's innovative Revenue Opportunity Model that measures actual revenue against a theoretical optimal and is a critical means to measure Revenue Management performance.

The success at Marriott was quickly followed by the adoption of the science at major North American hotel chains. Hilton, Holiday Inns and Sheraton all had notable successes in the 1990s as did Disney. The strategic levers of Revenue Management, including customer segmentation, forecasting, pricing and duration control, have also been adopted by related service industries such as cruise lines, restaurants and golf courses (Kimes, 2003).

A natural extension of hotel Revenue Management was to rental car firms, which had similar issues of discount availability and duration control. Revenue Management famously saved National Car Rental from bankruptcy, simultaneously saving 7500 jobs (Geraghty and Johnson, 1997).

The sports and entertainment industries are rapidly adopting these principles as well. Theaters, sports teams and even operas have had success in segmenting customers and offering differentiated pricing based upon the perceived



values of any individual event to various customer segments (Talluri and van Ryzin, 2004). The approach has been tremendously successful for live concerts in maximizing revenue for the best seats while offering deeper discounts to fill the worst ones. The ability of the practice to match price to actual market demand generates greater profits for the events while diminishing the need for consumers to go to the secondary market (that is scalpers) for tickets (Waddell, 2009).

Similarly, multi-family housing has made Revenue Management an essential component of its revenue generating strategy (Bousquin, 2008). The concept has subsequently been extended to businesses as diverse as the management of 'time inventory' for professional services firms such as accountants and lawyers (Dunn and Baker, 2003) and natural gas storage and transmission (Talluri and van Ryzin, 2004).

## **SCIENCE EVOLVES FROM B2C TO B2B – UNITED PARCEL SERVICE (UPS)**

The airline experience in adapting to a rapidly changing competitive environment was the impetus for UPS in the revitalization of their business and the creation of another milestone in the 1990s.

Since UPS's humble beginnings in 1907, the company had grown by adhering to founder Jim Casey's slogan, 'best service and lowest rates' by following strict policies of customer courtesy, reliability, round-the-clock service and low rates.

As it grew to 'common carrier' status over the decades, it believed that its primary competition was the US Postal Service. Rates were set on a cost-plus basis by filing tariffs with the federal government. Rates were kept low through relentless cost control, which thoroughly evaluated every operational movement and drove every decision from how many steps the deliveryman should take from the

truck to the door and in what order the keys should go on the drivers' key rings.

Arch-competitor FedEx was founded in 1971 but was not really considered a primary UPS competitor until the Motor Carrier Act of 1980. The Act deregulated the trucking industry and removed all regulatory restrictions on the ground movement of packages that were transported partly by air. This hastened UPS to develop a Louisville hub to compete directly with the FedEx hub in Memphis. By 1985, UPS had Next Day and Second Day Air service nationwide (Niemann, 2007).

At this time, however, UPS was still an operationally focused carrier and did not even have a marketing department. Many commercial accounts were beginning to demand discounts off the published tariffs. Faced with the need for volume growth in a very competitive market, Dan DiMaggio was brought from operations to be a marketing manager over air products. (Dan DiMaggio, 2010, personal communication)

DiMaggio and his counterpart on the ground side, Joe Pyne, recognized the need for disciplined processes to control discounts that were offered. They began building a pricing organization in 1991. Initially, discounting was limited to customers who could establish that they would have the volume to lower cost-of-service, and discounts were limited to them. However, competition intensified, and soon salespeople were requesting, and the pricing department was authorizing, hundreds of millions of dollars in discounts.

Unlike the experience at American and Marriott in which the adoption of sophisticated pricing and Revenue Management was driven by a visionary CEO, the adoption at UPS was a more slowly evolving, collaborative movement. At first, the focus was on understanding and controlling discounting. UPS created an enterprise-wide tool called the 'Incentive Administration System', which began to collect win/loss data from 100 000 commercial accounts. It was used to oversee and implement discounting decisions as well as contract

administration, execution and compliance (Rick Campana, 2010, personal communication).

This was a start, but UPS had a 'paramilitary DNA' that required 'mission success'. For the sales department, 'success' was defined as winning the business, and the most effective weapon seemed to be greater discounts. Prices began to erode rapidly.

The executive team at UPS knew that more assistance was needed to ensure that discounts were effectively targeted. They recognized the analogy with the airline industry where the practice of Revenue Management was a proven way to target discount seats. Rick Campana was named Vice President of Marketing. He assembled a group of former airline experts as well as outside consultants with extensive airline expertise (Dan DiMaggio, 2010, personal communication).

Marketing Director Mark Rudel and others recognized that their problem was different from airlines and hotels. Rather than optimizing the revenue for a discrete event such as the purchase of an airline seat or a hotel room, UPS was negotiating annual rates for large-volume customers using a multitude of services over the course of a year. They formulated the problem as a customized bid-response model that used historical data to predict the probability of winning at different price points. They called the system 'Target Pricing' (Mark Rudel, 2010, personal communication).

With Target Pricing, they were able to forecast the outcomes of any contractual bid at various net prices. They were able to identify where they could command a price premium over competitors and where deeper discounts were required to land deals. Incorporating cost data and strategic marketing objectives enabled them to give accurate price guidance to the sales force in any competitive bid situation. The result was more consistent and rational pricing for customers and long-term profit maximization for UPS (Campana, 2007). In the first year of Target Pricing in the mid-1990s, UPS reported increased profits of over \$100 million (Agrawal and Ferguson, 2007).

Other transportation firms have adopted the concepts of Revenue Management with extraordinary success. FedEx Chairman and CEO Frederick Smith attributed a significant portion of a 10 per cent revenue increase and 33 per cent growth in profits to Revenue Management and a 'disciplined pricing approach' (Boyd, 2006). Many shipping, trucking, rail and intermodal companies such as Yellow Freight and CSX have adopted the practice, although it is still not yet considered a standard practice in their industries (Talluri and van Ryzin, 2004).

The concept of maximizing revenue on negotiated deals found its way back to the hospitality industry. For years, Marriott's application of Revenue Management was limited to individual bookings, not groups or other negotiated deals. In 2007, Marriott introduced a 'Group Price Optimizer', which uses price elasticity models for each statistically derived market segment. Similar to UPS's Target Pricing, the system uses a competitive bid-response model that predicts the probability of winning at any price point, thus providing accurate price guidance to the sales force. The initial system generated an incremental \$46 million in profit (Hornby *et al*, 2010).

By the early 1990s Revenue Management also began to be applied to television ad sales. The first system, implemented for Canadian Broadcast Corporation in 1992, functioned similar to a traditional travel industry Revenue Management system. It forecasted demand and optimized hurdle points to open and close discount buckets (Cross, 1997). In the late 1990s Revenue Management was adopted by US network ad sales at American Broadcasting Company (ABC) (Mandese, 1998) and National Broadcasting Company (NBC) (Bollapragada *et al*, 2002). The very different nature of the US market required a different approach. The US network ad sales market is dominated by 'the upfront', a period that starts in late May after new schedules are announced and during which 70–90 per cent of inventory is committed in proposals for annual ad campaigns. What evolved at the networks was



proposal optimization. These systems automated the placement of ads in proposals based on total forecasted demand and forecasted ratings by program. Today, many television networks around the globe have revenue management systems (Bell, 2005).

## **APPLICATION TO NON-PERISHABLE INVENTORY – FORD MOTOR COMPANY**

Until the mid-1990s, the Ford Motor Company followed the typical business model engaged by most manufacturers. Once a vehicle was placed into production, operational considerations of the producing plant required that units be produced at a rigorously controlled pace. Price incentives were used on an *ad hoc* basis to move excess inventory in a rough attempt to balance supply with demand for individual products.

The economic recession in the early 1990s created a time of uncertainty and stress, which required Ford to re-evaluate many of its practices in order to return to the level of profitability that *Wall Street* demanded. Lloyd Hansen, Corporate Controller for Global Marketing and Sales, was just one of the many executives seeking a better way to drive profitability. Though his background was in Finance and he had developed a reputation as a fierce cost cutter, he was convinced that another round of cost-cutting was not the answer (Mohammed, 2005).

Hansen was inspired by the successes of airlines, hotels and rental car firms, which used Revenue Management to maximize profitability by segmenting customers into ‘micro markets’ and create a differentiated and targeted price structure. (Hansen, 2005) However, the application of the principles from those industries was not straight forward.

Pricing for vehicles and options packages were set based upon annual volume estimates and profitability projections. The company invariably found that certain products were overpriced and some were underpriced (Coy, 2000).

Ford had used ‘marketing programs’ that were typically incentives such as dealer rebates, customer cash-back and subsidized interest rates to discount slow moving vehicles and make up for pricing missteps. However, those programs were generally broad-ranging national events. Hansen knew that customers’ perception of value varies based on geography (trucks are more highly valued in the Southwest than the Northeast), vehicle type (truck buyers are more sensitive to cash rebates than car buyers) and product configuration (certain add-ons are much more valuable than their incremental cost) (Cross and Dixit, 2005).

Understanding the wide range of customer preferences across a broad product line and expansive geographical market required significant data gathering, analysis and experimentation. Hansen created a Revenue Management organization and brought in outside consultants with airline and hotel experience to measure the price-responsiveness of different customer segments for each incentive type and to develop an approach that would target the optimal incentive by product and region.

The result was a ‘stunning’ ability to make more money without making more vehicles. By the end of the decade, Ford estimated that about \$3 billion in additional profits came from Revenue Management initiatives (Leibs, 2000).

The great public success of Pricing and Revenue Management at Ford solidified the ability of the discipline to address the revenue generation issues of virtually any company. Many auto manufacturers are adopting the practice for both vehicle sales and the sale of parts. General Motors’ Service and Parts Organization attributed \$100 million in revenue increases to the adoption of the science (Neville, 2007).

Retailers have leveraged the concepts pioneered at Ford to create more dynamic, targeted pricing in the form of discounts and promotions to more accurately match supply with demand. Promotions planning and optimization assists retailers with the timing and prediction of the incremental lift of a

promotion for targeted products and customer sets. Markdown optimization is being rapidly adopted to maximize revenue from end-of-season or end-of-life items (Phillips, 2005).

## **REVOLUTION IN TRAVEL AND TRANSPORTATION – INTERCONTINENTAL HOTELS GROUP (IHG)**

By the late 1990s, virtually all major airlines, hotel firms, cruise lines and rental car firms had implemented Revenue Management systems to predict customer demand and optimize available price. However, ‘optimize’ had been narrowly defined as it was limited to managing the availability of pre-defined prices in pre-established price categories. The objective function was to select the best blends of predicted demand given existing prices. The sophisticated technology and optimization algorithms had been focused on selling the right amount of inventory at a given price, not on the price itself.

After the tragic events of 9/11, a number of hotel firms recognized that traditional Revenue Management systems simply opened the lowest rates available, thus raising the question, ‘How low should we go?’ (Cross *et al*, 2009). Another concern was the fear of a ‘race to the bottom’. A 2006 study on Yield Management practices in the travel industry demonstrated that a downward spiral in prices can result from a naïve application of the principle that inventory predicted to be empty should be made available at the lowest pre-defined price (Cooper *et al*, 2006).

Realizing that controlling inventory was no longer sufficient, IHG launched an initiative to better understand the price sensitivity of customer demand. The result of the initial elasticity studies by Craig Eister, VP Revenue Management and Dev Koushik, Director, Revenue Optimization were encouraging. They could measure absolute elasticity, but they needed to give each individual hotel more accurate pricing guidance.

Calculating price elasticity at very granular levels to a high degree of accuracy was not enough. Rate transparency had elevated the importance of incorporating market positioning against substitutable alternatives. IHG recognized that when a competitor changes its rate, the consumer’s perception of IHG’s rate also changes (Cross *et al*, 2009).

IHG teamed with an outside consulting firm that had experience with analytically based pricing in multiple industries. Working with third-party competitive data, the team was able to analyze historical price, volume and share data to accurately measure price elasticity in every local market for multiple lengths of stay. These elements were incorporated into a system that also measured differences in customer elasticity based upon how far in advance the booking is being made relative to the arrival date.

The incremental revenue from the system was significant. The Price Optimization capability increased Revenue per Available Room by 2.7 per cent (InterContinental Hotels Group, 2009). One of the keys to the system’s success was tight integration with the existing PERFORM Revenue Management system used for inventory control. The new Price Optimization system continually evaluates a hotel’s demand, incorporates real-time competitive rates and assesses the price elasticity of its customers. It recommends the best price that will maximize revenue opportunities, greatly simplifying a complex task.

The ability to simultaneously optimize price based on forecasted demand, price elasticity and competitive rates has obvious benefits. Leading hotel firms such as Marriott and Carlson (Cross *et al*, 2009) as well as Starwood (Peyton, 2009) are adopting this revolutionary twist on Revenue Management.

## **MILESTONES ON THE HORIZON**

Because of the groundwork laid by so many firms, the journey for others is being accelerated. Progress is being made on many fronts



taking Revenue Management in new directions, both in terms of extension to new industries and expanded capabilities with existing practitioners. There have been other significant successes, but they have not yet achieved sufficient public visibility, which is the hallmark of a milestone. We would like to identify a few, which we believe may be milestones in the future.

One of the most promising is the application to the multi-trillion dollar financial services industry. The analytical approaches pioneered in travel and transportation have great potential in helping banks and other lenders better understand customer segmentation and target more accurate lending rates to different customer segments. Lenders have long used great sophistication with respect to assessing customer risk, but similar rigor has not been applied to pricing strategy and assessing customer value (Kadet, 2008). Some banks and auto lenders have seen initial successes with price optimization, but the inherent secrecy of the lending process has inhibited broad public declarations of success that are required for a 'milestone' event (Reeves, 2009).

Integration of pricing and Revenue Management with the supply chain presents a great opportunity to expand this science. Using price alone to balance supply and demand has its risks. It has been recognized that overcapacity will inevitably lead to lower prices and rampant discounting, while raising prices in an environment of constrained capacity may divert profitable customers and encourage competition. For airlines, insights into price elasticity and customer demand have been used to inform scheduling decisions; however, it is not yet an integrated process (Jacobs *et al.*, 2010). More promising may be work performed in rental car fleet planning (Pachon *et al.*, 2006) and consumer package goods where the ability to adjust supply rapidly to meet demand makes end-to-end optimization more feasible (Bippert, 2009).

The integration of CRM and Revenue Management is another area with great potential. Most pricing and Revenue Management

databases are not tightly linked with CRM databases and customer relationship is generally not taken into account except for customized deals for volume accounts (Milla and Shoemaker, 2007). Especially intriguing is the possibility of optimizing the lifetime revenue from a customer. To date, Revenue Management and Price Optimization systems have been tremendously effective in optimizing revenue on a case-by-case transactional basis. This is not a sufficiently long-term revenue generating perspective. Casinos have seen some success in integrating data from CRM systems and player-tracking systems to predict total customer spend when establishing room rates for a potential guest staying at the property (Metters *et al.*, 2008). The ability to understand total customer contribution over time and to optimize price and inventory availability for customers based on estimates of longer-term profit potential may prove to be a major milestone for others to follow.

## CONCLUSION

As we review the notable milestones to synthesize our learning, we see that there are a number of common threads or 'unifying themes' that are valuable to discuss.

The first is that the milestones were not created by people who were trying to expand the discipline or devise innovative applications of a useful technology. They were just trying to solve an urgent business issue. The need to proactively address a market shift by getting out of one's comfort zone was driven by senior vision and leadership. Typically a relatively small team of people were engaged to drive the change that was transformational for an entire company.

The focus for change was external, not internal. Milestone-creating companies became more customer-centric and less product-centric. They leveraged existing technology while creating some new techniques for collecting and analyzing transactions at a granular level to predict customer response. They

formed organizations and defined new processes. But most importantly, they had remarkable success.

They knew that they were embarking on a new journey, and they expected to succeed. They occasionally established new metrics. They invariably measured outcomes and eliminated obstacles to success. Their achievements have been inspirational for others and illustrative of the fact that advances in Pricing and Revenue Management have no boundaries.

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