Chapter 2
Concepts and Application

2.1 The Concepts of RM and PI

When offering a product or a service the seller faces a number of complex decisions.[1] For example, which is the price that shall be asked? How shall prices be adjusted over time? How shall buyers be segmented by e.g. providing different conditions? Who should prices be varied across segments? If a product is short in supply, to which segment or channel should the products be allocated? These are only some of the questions that arise in the selling process. RM can provide answers to these questions.

2.1.1 Definition of RM

The notion of RM encompasses the strategies, tactics and tools aiming at the maximization of revenues by allocating a company's capacity to different customers at different price levels. Its success has led to widespread application of RM. However, with strong origins in the airline industry, this industry and the service industries in general are nowadays its main field of application.

RM[2] covers the systematic use of tactical and operational instruments to maximize revenue for capacities that are fixed in the medium term, for stochastic demand and for cases where there is no make-to-stock (MTS) production option available and is employed in the services industries and more recently also in the manufacturing industries. In the latter, it is used e.g. in a make-to-order (MTO)

[1] This chapter has been integrated with inputs adapted from Talluri and van Ryzin (2004) with the kind permission of Springer.

[2] Alternative names for RM are the English terms yield management, revenue optimization and demand management (Talluri and van Ryzin 2004).

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production environment, where customers specify their order previous to the production process and suppliers unable to satisfy the incoming demand from stock (Müller-Bungart 2006). The use of RM in MTO production processes has received consideration by different authors, e.g. Defregger and Kuhn (2007), Hintsches et al. (2009), Quante et al. (2009), Spengler and Rehkopf (2005), and Spengler et al. (2008).

2.1.2 Definition of PI

The PI contains businesses that add value to materials by mixing, separating, forming, or chemical reactions. Processes may be either continuous or batch and generally require rigid process control and high capital investment (Wallace 1984).

Examples of PI include food, beverages, chemicals, pharmaceuticals, petroleum, ceramics, base metals, coal, plastics, rubber, textiles, tobacco, wood and wood products, paper and paper products, etc. (IIE 2013). The process industry accounts for more than 50 % of the industrial sector's GNP in several western countries, e.g. 58 % in Germany (Destatis 2013). Given its weight, the PI was chose a focus industry for the manufacturing sector.

2.2 Demand-Management Decisions

There are three basic demand-management decisions that RM addresses:

(1) Structural decisions: which segmentation or differentiation mechanisms to use, if any; which selling format to use, such as posted prices, auctions or negotiations; which trade terms to offer (including volume discounts and cancellation or refund options); how to bundle products; and so on.
(2) Pricing decisions: how to set posted prices, individual-offer prices, and reserve prices (in auctions); how to price across product categories; how to price over time; how to markdown (discount) over the product life cycle; and so on.
(3) Quantity decisions: whether to accept or reject an offer to buy; how to allocate output or capacity to different segments, products or channels; when to withhold a product from the market and sale at later point in time; and so on.

Which of these decisions is most relevant in any given business depends on the context. The timescale of the decisions also varies. Structural decisions about which mechanism to use for selling and how to segment and bundle products are normally strategic decisions taken relatively infrequently. Companies may also have to commit to certain price or quantity decisions, for example, by advertising prices in advance or developing capacity in advance, which can limit their ability to adjust quantities or prices on a tactical level. The ability to adjust quantities may also be a function of the technology of production—the flexibility of the supply process and

the cost of reallocating both capacity and inventory. The use of capacity controls for example as a tactic in airlines stems largely from the fact that the different "products" an airline sells (different ticket types sold at different times and under different terms) are all supplied using the same, homogeneous seat capacity. This gives airlines tremendous quantity flexibility, so quantity control is a natural tactic in this industry. On the other side retailers often commit to quantities, e.g. initial stocking decisions, but have more flexibility to adjust prices over time. However, the ability to price in a tactical manner depends on how costly price changes are, which can vary depending on the channel of distribution such as online versus catalog.

Whether a company uses price- or quantity-based RM controls varies even across companies within a given industry. For example, while most airlines commit to fixed prices and tactically allocate capacity, low-cost carriers tend to use price as the primary tactical variable.

Companies can also find innovative ways to increase their ability to make price or quantity resource decisions. For instance, retailers may hold back some stock in a centralized warehouse and then make a mid-season replenishment decision rather than precommit all their stock to stores upfront. Some major airlines have experimented with movable partitions that allow them to reallocate seats from coach to business cabins on a short-term basis. And other major airlines have experimented with a practice called demand-driven dispatch (D^3), in which aircrafts of different sizes are dynamically assigned to each flight departure in response to fluctuations in demand, and are not precommitted to flights. Car rental companies also may reallocate their fleet from one city to another. When it comes to pricing, using online channels or advertising products without price ("call for our low price") provides companies with more price flexibility. All these innovations increase the opportunity for quantity and price-based RM.

Broadly speaking, RM addresses all three categories of demand-management decisions—structural, pricing, and quantity decisions. We quality RM as being either quantity-based RM or price-based RM if it uses (inventory- or) capacity-allocation decisions or prices as the primary tactical tool respectively for managing demand. Both the theory and practice of RM differ based on which control variable is used.

2.3 The Innovative Elements of Revenue Management

RM can be seen as a very old idea. Every seller in human history has taken RM-type decisions after having been confronted with a set of similar questions. What price shall be asked? Which offers shall be accepted? When shall the price be reduced? And when to simply "pack up one's tent" and leave the market as it were and try selling at a later point in time or in a different market. In terms of business practices, the problems of RM are as old as business itself.

In terms of theory, at a broad level the problems of RM are not new either. In fact, the forces of supply and demand and the resulting process of price information—the "invisible hand" of Adam Smith—lie at the heart of our current understanding of market economics. They are embodied in the concept of the "rational", i.e. profit-maximizing, company, and define the mechanisms by which market equilibria are reached. Modern economic theory addresses many advances and subtle demand-management decisions, such as nonlinear pricing, bundling, segmentation, and optimizing in the presence of asymmetric information between buyers and sellers.

The new element about RM is not the demand-management decisions themselves but rather *how* these decisions are made. The true innovation of RM lies in the method of decision making a technologically sophisticated, detailed, and intensively operational approach to making demand-management decisions.

This new approach is driven by two complementary forces. First, scientific advances in economics, statistics, and operations research now make it possible to model economic conditions and demand, quantify the uncertainties faced by decision makers, estimate and forecast market response, and compute optimal solutions to complex decision problems. Second, advances in information technology provide the capability to automate transactions, capture and store vast amounts of data, quickly execute complex algorithms, and then implement and manage highly detailed demand-management decisions. This combination of science and technology applied to age-old demand management is the hallmark of modern RM.

And both the science and technology used in RM are quite new. Much of the science used in RM today (e.g. forecasting methods, demand models, optimization algorithms) is less than 60 years old. Most of the information technology (e.g. Internet, personal computers, large databases) is less than 30 years old, and most of the software technology (e.g. object-oriented programming, Java, etc.) is less than 5 years old. Prior to these scientific developments, it would have been unthinkable to accurately model real world phenomena and demand-management decisions. Without the information technology, it would be impossible to operationalize this science. These two capabilities combined make possible an entirely new approach to decision making—one that has profound consequences and benefits for demand management.

The first consequence is that science and technology now make it possible to manage demand on a scale and complexity that would be unthinkable through manual means, or would require a veritable army of analysts to be completed. A large airlines, for example, can have thousands of flights per day, providing service between hundreds of thousands of origin-destination pairs, each of which is sold at dozens of prices—and this entire problem is replicated for hundreds of days into the future! A similar complexity is typically found at large retail chains, which have tens of thousand of SKUs[3] sold in several hundreds of stores and over the Web with

[3] A SKU, i.e. stock keeping unit, is the lowest level at which we identify inventory—such as men's Arrow blue Oxford shirts, long sleeves, size medium.

prices monitored and updated on a daily basis. The sheer scale and complexity of the decisions-making task in these cases is beyond the ability of human decision makers. If not automated, the task has to be so highly aggregated and simplified that significant opportunities for incremental gains—on particular products, at particular locations, at specific points in time, are simply lost.

The second consequence is that today it is possible to improve the *quality* of demand management decisions, which also leads to significant revenue increases. Complex assessments of demand development, willingness to pay, price thresholds, price setting, capacity constraints, volume vs. profit tradeoffs and so on are tasks most humans, even with many years of experience, are simply not good at. Systems and tools are better at assessing, optimizing and generating consistent decisions. This is especially true for routine RM decisions that are automated through the systems. However, human analysis is required: these decisions need to be overseen and human intervention is required e.g. when flags or alerts indicate extraordinary situations. Tools and algorithms can only detect what is contained in the data—they are not able to reason or anticipate e.g. a sudden price move of a competing company, a demand shock, an unforeseen change in customer preferences and so on. The best of both machine and human decision-making is a man-tool interaction that provides the advantages of the automated analyses combined with the monitoring of the analysts[4] within a company.

Modern RM can be defined as the management of demand decisions with the support of science and technology, which is implemented with a structured process and supporting tools and overseen by analysts. It can be summarized as the *industrialization* of the entire demand-management process.

2.4 Origins of RM

The history and origins of RM are strictly connected to a single industry, namely the U.S. airline industry in the 1970s (Belobaba 1989; Lindenmeier and Tscheulin 2003; Littlewood 1972; Rothstein 1971; Smith et al. 1992; Weatherford and Bodily 1992). Business practices whose origins are so intimately tightly linked to a single industry like in the case of RM are rare. A short overview of the history of airline RM and its implications follows below.

[4] These analysts are also indicated in the organigrams of companies Revenue Manager, Yield Manager, Pricing Manager or Demand Manager.

2.4.1 Airline Industry in the 1970s

The trigger for the development of RM was the airline fare deregulation. The Civil Aeronautics Board (CAB) regulated the U.S. airline industry until 1978, strictly controlling e.g. airline fares, entry of airlines into and offerings related to different destinations. With the Airline Deregulation Act of 1978, the U.S. Civil Aviation Board phased out state control of airline fares, allowing airlines to freely set prices, schedules and services (Bailey et al. 1985; Morrison and Winston 1995).

The deregulation of the airline industry opened up the market to low cost carriers, which started competing on price with major airlines. This new situation forced major airlines to quickly develop RM approaches to respond to the offerings of the new competitors (Talluri and van Ryzin 2004): they were now free to change prices, schedules, and service without CAB approval. Established carriers thus invested in fast developments of computerized reservation systems (CRSs) and global distribution systems (GDSs), and the GDS business became profitable in its own right. Another development initiated by large airlines were hub-and-spoke networks, which allowed them to offer service in many more markets than was possible with point-to-point service but also made pricing and operations more complex to manage.

New low-cost and charter carriers stepped into the market and were able to profitably price much lower than established airlines, because of their lower labor costs, simpler point-to-point operations and no-frills offering. These new players unlocked an entirely new and vast demand for discretionary travel, e.g. families on a holiday, couples getting away for the weekend or college students visiting home, many of whom might otherwise have driven their cars, taken a bus or not travelled at all. One of the main findings—quite surprisingly to some at the time—was that air travel was quite price elastic: with prices sufficiently low, people switched from driving to flying, and demand from this segment surged. People Express can be taken as a good example of one of these successful and strongly growing players, which started in 1981 with fares 50–70 % lower than established carriers and cost-efficient operations. Only after 3 years, in 1984, its revenues were around $1 billion, with a profit of $60 million (Cross 1997).

The consequence of the new low-cost offerings was a visible shift of price-sensitive discretionary travelers to the new budget airlines. However, established carriers still had strengths, that these new entrants lacked: they offered e.g. more frequent schedules, service to more city pairs and established brand names and reputation. For several business travelers, schedule convenience and service was and still is more relevant than price. The threat represented by budget airlines was therefore less acute in the business-traveler segment of the market. Still, the cumulative losses in revenue from the migration in traffic were heavily damaging the profits of large airlines.

Thus, incumbents needed to recapture the leisure passengers. However, for the majors, a head-to-head price war against the upstarts would have been suicidal: with significantly lower costs, airlines like People-Express could still earn a profit at

the new low prices, while most established airlines would lose money at a staggering rate.

2.4.2 Innovations Introduced by American Airlines

One of the key incumbents, namely American Airlines, adopted a price differentiation approach to offer discounts with purchase restrictions. With this new mechanism, American Airlines successfully responded to the challengers with a new offering for price sensitive leisure travelers without putting at stake revenues generated by inelastic business travelers. Robert Crandall, vice president of marketing at American Airlines at that time, is widely credited with the breakthrough in solving this problem. He understood that his airline was already producing seats at a marginal cost near to zero because most of the costs of a flight, i.e. capital costs, wages and fuel, are fixed. Therefore, American Airlines could in fact afford to compete on cost with the upstarts using its surplus seats.

Despite having laid the foundation to find a solution to the competitive moves of budget airlines, Crandall needed to solve to issues before being able to execute a new strategy. First, American Airlines had to find a way of identifying the surplus seats on each flight. If a sale of a low-priced seat would displace a high-paying business customer, this scheme would clearly reduce overall profits. Second, it needs to be ensured, that business customers do not switch and buy the new low-cost products that are meant to discretionary, leisure customers.

American Airlines found a solution to the two issues above using a combination of purchase restrictions and capacity-controlled fares. Discounted fares had significant restrictions for purchase: they were nonrefundable, required a 7 day minimum stay and had to be purchased 30 days in advance of departure. With such restrictions, American Airlines prevented most business travelers from utilizing the new low fares. In parallel to this, they limited the number of discount seats sold on each flight: American Airlines capacity-controlled the fares. With these two elements American Airlines had the means to compete on price with the budget carriers without damaging their core business-traveler revenues. This new pricing scheme was launched 1978 and called American Super-Saver Fare. They were quite effective at stemming the tide of defections of discretionary travelers to the budget carriers.

After the initial success of the new strategy, the roll-out of it to the whole product offering experienced significant issues. The capacity controls of American Airlines were namely based on setting aside a fixed portion of seats on each flight for the new low-fare products. However, as American Airlines cumulated experience with its Super-Saver fares, it also discovered that not all the flights were the same. Flights at different times of a day or on different days had different patterns of demand. Some had many excess seats and could profitably support a higher allocation of discount seats; others had sufficient demand for regular-priced seats and warranted very little if any allocation to the new, discounted products.

Robert Crandall realized thus, that he needed a more intelligent approach to realize the full potential of capacity-controlled discounts. The development of what became known as the Dynamic Inventory Allocation and Maintenance Optimizer system (DINAMO) was initiated. DINAMO represents the first large-scale RM system in the airline industry: it was large and complex and took several years to develop and refine.

The full implementation of DINAMO was reached in January 1985 along with a new fare program called Ultimate Super-Saver Fares, which matched or even undercut the lowest discount fares available in every market in which American Airlines operated. DINAMO enabled American Airlines to beat competition. In fact, American Airlines became much more aggressive on price. It was able to offer fares that spanned a large swath of individual flights, confident in it capability to accurately capacity-control the discounts on each individual departure. In addition, competitors could not observe American Airline's capacity controls unlike prices themselves, which, thanks to GDSs, instantly became public information. This peculiarity of pricing aggressively and competitively at an aggregate, market level, while controlling capacity at a tactical, individual-departure level still characterizes the practice of RM in the airline industry today.

The new competitive power the American Airlines gained from the RM-weapon DINAMO was dramatic. People-Express was especially hard hit as American Airlines repeatedly matched or beat their prices in every market it served: its annual profit fell from an all-time high of $60 million in 1984, i.e. the year before the implementation of DINAMO, to a loss of $160 million by 1986, i.e. 1 year after DINAMO was launched. The mounting losses lead to the bankruptcy of People-Express and in 1986 the company was sold to Continental Airlines.

Nowadays RM is widespread in the airline industry and reached a high maturity level, with RM being considered as critical to running a modern airline profitably. American Airlines, for instance, indicates that its RM practices generated $1.4 billion in additional incremental revenue over a 3-year period starting around 1988 (Smith et al. 1992). Several other airlines all over the world similarly attribute a significant share of both revenues and profits to their RM approaches.

2.4.3 Implications of the Airline Heritage

The intimate heritage of RM from the airline industry can regarded both as a blessing and curse for the field of RM. The blessing is that RM can present a major success case in an industry in which the practice of RM is heavily contributing to revenue and profit gains, is highly sophisticated and pervasive on a global scale. Without RM a high number of established carriers would not be able to operate in a profitable way.[5] The complexity and scale of RM at large carriers is

[5] See Sect. 2.8 "Profit Impact of RM".

truly mind-blocking. Thus the airline success story validates both the feasibility of executing RM reliably in a complex business environment and the economic impact of RM.

The curse of the strong heritage of RM from the airline industry is that it has created some kind of myopia inside its application field. A number of researches and practitioners regard RM as solely airline-specific. This lead to the creation of biases that have hampered both implementation efforts and research in other industries. An additional issue is that this airline-specific association of RM tends to have a bad reputation among consumers. On one hand customers appreciate the very low fares that RM made possible but on the other the fares are perceived as complex, sometimes so dynamic that good prices go away from minute to the other and discriminating when consumers realize that two persons sitting side by side on a flight are paying drastically different prices. This lead to hostility towards RM in other industries and reluctance to try its practices.

In reality, when moving from the airline industry to other industries, applying RM means disclosing untapped revenue potentials and increasing significant profit margins. Applying RM typically does not involve radically changing the structure of pricing and sales practices. It rather is a matter of making more intelligent decisions.

2.4.4 Extension to Other Service Industries

Starting with Littlewood's research (1972), there is an immense amount of work on RM planning approaches for the service industry, especially for the airline industry. An overview can be found, for example, in Talluri and van Ryzin (2004). Likewise, there are a range of empirical studies on RM in the service industry. In this sector, Kimes (1994), Kimes and Wirtz (2003a, b) and Wirtz and Kimes (2007) examine the extent to which customers perceive RM to be fair. Wangenheim and Bayón (2006, 2007) analyze the impact of an airline's RM measures on customer satisfaction and Crystal (2007) examine the success factors for RM in the hotel industry.

As the production-inflexibility peculiarities of airlines are shared by many other service industries, RM is strongly associated with the service industry in general. In addition to the airline industry, RM has also been used in many other service industries, such as car rental, hotels, apartment renting, casinos, saunas, golf, cruise lines, entertainment events, conferences, sport events, railways, gastronomy, health, Internet, broadcasting, media, TV services, cellular network services, cargo and logistics (Chiang et al. 2007; Defregger and Kuhn 2007; Klein and Steinhardt 2008; Kuhn and Defregger 2005a, b; Talluri and van Ryzin 2004).

An adopter of RM has also been the energy sector, principally in the area of managing the sales of pipeline capacity for gas transportation. Also in the energy sector demands are volatile and uncertain, and the technology for generating and transmitting electricity and gas can be inflexible. In addition, the deregulation of

this industry led to a lot of experimentation and innovation in the pricing practices of energy, gas and transmission markets.

The adoption of RM has also been reported in the retail industry. Especially fashion apparel, toy and consumer electronics sectors were the early adopters of RM within the retail players. The reason for this is that retail demand is highly volatile and uncertain, supply is quite inflexible, consumers' valuations change rapidly over time, and short selling seasons are combined with long production and distribution lead times. The introduction of bar and QR codes as well as the point-of-sale (POS) technology has made it possible to achieve a high degree of automation of sales transactions for most major retailers.

In terms of future application of RM one could argue, that many industries are potential candidates for RM. Almost all companies must deal with demand variability, uncertainty, and customer heterogeneity. Most are subject to some sort of supply or production inflexibility. The progress made on enterprise software and e-commerce innovations enabled many companies to automate their business processes. All these elements bode well for the future widespread of RM.

However, as with any technological and business-practice innovation, the case for RM ultimately boils down to a cost-benefit analysis for each individual firm. For some firms, the potential benefit will simply never justify the costs of implementing RM systems and business processes. Nevertheless, it is likely that for the majority of firms, RM will eventually be justified once the technology and methodology in their industry matures. In fact, the history of RM in industries such as airlines, hotels, and retail suggests that once the technology gains a foothold in an industry, it spreads quite rapidly. Therefore it would not be a surprise, if we will see RM systems or systems performing RM functions under a different denomination become as ubiquitous as ERP, SCM, and CRM systems are today.

2.5 RM in the Manufacturing Industry

While research in the service industries has been concerned with the optimal usage of limited capacity resources since the end of the 1970s, research in manufacturing is a relatively young scientific discipline compared to the former (Chiang et al. 2007). Recently, research on RM has been extended to its application in the manufacturing industry (Barut and Sridharan 2005; Watanapa and Techanitasawad 2005a; Defregger and Kuhn 2007; Spengler et al. 2007).

The first studies investigated the applicability of RM concepts to the manufacturing industry, concluding that RM can be applied in many manufacturing industries such as paper, steel and aluminium (Blumenthal et al. 2008), iron and steel (Spengler et al. 2007), automotive (Blumenthal et al. 2008; Voigt et al. 2008) or assemble-to-order (Harris and Pinder 1995).

2.5.1 Planning Approaches

Planning approaches for the use of RM in the manufacturing industry have only appeared comparatively recently. The works differ with regard to the control parameters of approaches to deciding on the acceptance of orders for requests with a fixed price and date (Defregger and Kuhn 2007; Elimam and Dodin 2001; Kimms and Müller-Bungart 2003; Kniker and Burman 2001; Spengler and Rehkopf 2005; Spengler et al. 2007), approaches to defining delivery dates for orders with a fixed price (Keskinocak et al. 2001) and approaches to defining offer prices and delivery dates for order requests (Charnsirisakskul et al. 2006; Watanapa and Techanitasawad 2005a, b). However, these works are of a conceptual and normative nature and, with the exception of a number of case studies, fail to address the state of revenue management in the manufacturing industry.

So far little empirical research is available on the use of RM in general (see Weatherford (2009) for survey results on the deployment of RM software in the airline industry) and on the use of RM in the manufacturing industry in particular.

2.5.2 Empirical Studies

To the best of our knowledge, the only empirical study on the use of RM in the manufacturing industry besides our research (Kolisch and Zatta 2009, 2012, 2014) was conducted by Kuhn and Defregger (2005a, b).

Based on 107 companies from the paper, steel and aluminium industries, this study examines the extent to which the conditions are in place in the aforementioned industries for the use of RM and the extent to which RM is currently applied. Based on this sample, it is estimated that approximately 60 % of companies in the aforementioned industries meet the conditions to apply revenue management, but that RM is not yet being used extensively. Prerequisites, importance, period of use and type of application (capacity versus price-based RM) have been assessed (Kolisch and Zatta 2009; Kuhn and Defregger 2005a, b; Talluri and van Ryzin 2004).

2.5.3 Manufacturing Alternatives: MTS vs. MTO

When applying RM to manufacturing companies, a distinction between make-to-stock (MTS) and make-to-order (MTO) scenarios needs to be made.

Typically MTS manufacturers, like consumer goods producers, produce large quantities of a relatively standardized product, based on forecast of future demand. The trade-off that companies face in this case is between the fulfilment of stochastic and uncertain demand patterns and both production and inventory costs.

While dynamic pricing tends to be the exception, most MTS manufacturers price based on aggregate decisions, however allowing end-of-life-cycle discounts or trade promotions (Coy 2000).

MTO manufacturers are typically characterized by smaller volumes produced, usually generated by business-to-business orders. Pricing of continuous streams of bids and requests for quotes are distinctive pricing elements, and pricing decisions are influenced by factors as estimated costs like materials, machine time and labour rates as well as strategic customer-life-cycle analyses. Activity-based pricing approaches are considered efficient RM tools in this context (Daly 2002).

After acceptance, orders are scheduled into the manufacturer's production planning and supply chain management system, where current and new orders are optimally coordinated. While it is the guiding principle to meet delivery due-dates at the lowest cost, neither pricing considerations as a regulatory mechanism for incoming orders nor price incentives to reduce production-peaks represent common practices (Talluri and van Ryzin 2004).

Production planning models for production capacity optimization in a combined MTS and MTO production environment have recently been proposed by researchers, opening up new opportunities to apply RM in the manufacturing arena (Tsubone and Kobayashi 2002).

2.6 Prerequisites for the Application of RM in the Service vs. PI

A range of conditions for the successful use of RM are stipulated in the available literature (Kimms and Klein 2005; Klein and Steinhardt 2008; Kuhn and Defregger 2005a, b; Netessine and Shumsky 2002; Talluri and van Ryzin 2004). Several works (Harris and Pinder 1995; Kimms and Müller-Bungart 2003; Kuhn and Defregger 2005a, b) examine the conditions for application of revenue management with respect to the MTO manufacturing of tangible goods and come to the conclusion that these conditions can essentially be deemed to have been met (Table 2.1).

In Table 2.1 the column "process industry" only displays the differences to the service industry. Blank spaces in this column indicate that the same condition also applies to the PI.

2.6.1 Heterogeneous Demand and Customer Segmentation

Demand heterogeneity is expressed by the fact that customers display variations in willingness to pay (WTP), in preference for different products, and in purchase behaviour over time. The more articulated the heterogeneity in customer needs, the

Table 2.1 Comparison of conditions for applying RM to the service and process industries (see also Talluri and van Ryzin 2004, pp. 13–16, 574–576; Watanapa 2004)

Service industry		Process industry
1.	Heterogeneous demand and opportunity for customer segmentation.	
2.	Stochastic demand.	
3.	Capacity is available in discrete periods and expires at the beginning of a period. Orders are assigned precisely to individual periods. As a result, sequencing is not necessary.	Capacity is constantly available and constantly expires. The delivery of the order takes place at a certain point in time. Sequencing of orders is necessary.
4.	Largely fixed capacity and dynamic demand.	Largely fixed capacity and dynamic demand which is determined by the delivery dates requested by the customer, the state of resources and the result of scheduling. Changes in availability are possible within certain limits by adjusting the intensity.
5.	High fixed costs and low marginal costs.	
6.	Pre-booking option.	
7.	Economic freedom to act.	
8.	Data availability and information systems.	
9.	Corporate culture and management support.	

more opportunities arise to use revenue management to strategically and tactically maximize revenues within different market segments.

Heterogeneous demand and the possibility to segment customers based on their WTP certainly characterizes both the services and manufacturing industries. They both have different patterns of usage and behaviour in terms of when they purchase and how flexible their demand is, and they place very different valuations on the need to purchase services.

2.6.2 Stochastic Demand

Demand varies according to season, week, day, and time of day. The more uncertain demand is, the harder it becomes to take future demand-management decisions. Forecasting time-related demand to effectively take pricing and allocation decisions thus becomes a critical success factor both in services and manufacturing industries.

2.6.3 Capacity Expiration

In the service industry capacity is available in discrete periods and expires at the beginning of a period. Orders are assigned precisely to individual periods. As a result, sequencing is not necessary. In the PI capacity is constantly available and

constantly expires. The delivery of the order takes place at a certain point in time. Sequencing of orders is necessary.

Since RM is typically used in a context where services are extremely perishable or cannot be stored at all there is limited or no arbitrage opportunity for the services. The same concept applies to manufacturing firms, because manufacturing capacity is as perishable as an airline seat or an advertising slot: if it is not used when it is available, that opportunity to use capacity is gone forever.

2.6.4 Fixed Capacity and Dynamic Demand

In the short run capacity is considered as fixed, even though companies can adapt their capacity by adjusting available units, e.g. by changing the aircraft use to a larger or smaller one. However, with an increasing degree of production inflexibility, the more production delays, economies of scale, switch-over costs and fixed capacity constraints exist, the more cost-intensive it becomes to match demand with supply variations. Thus, the higher fixed capacity is, the more strategically relevant revenue management becomes.

In the service industry capacity is largely fixed and demand is dynamic. In the process industry capacity is also largely fixed. Demand is also dynamic and it is determined by the delivery dates requested by the customer, the state of resources and the result of scheduling. Changes in availability are possible within certain limits by adjusting the intensity.

2.6.5 High Fixed Costs and Low Marginal Costs

The application of RM is characteristic of industry structures with a fixed cost component which is significantly larger compared to the variable cost component. Once, as an example, a restaurant has facilities and staff in place, the marginal cost of an additional client is relatively low when expressed in terms of food and drinks served as well as laundry and dishwashing. Therefore the revenue generated must cover variable costs and offset at least part of the fixed costs. This is true for both the services and manufacturing industries.

2.6.6 Pre-booking Option

The service is usually booked or purchased in advance of consumption, e.g. in the car rental industry. The same applies to manufacturing capacities, e.g. in the pharmaceutical industry.

2.6.7 Economic Freedom to Act

In the airline industry, for example, companies can withhold seats from current economy customers in order to make them available to future, more profitable business customers without being morally irresponsible or acting illegally. The same applies to manufacturing companies and their economic freedom to act.

However, such practices are not admissible in emergency wards or when allocating organs for transplantation.

2.6.8 Data Availability and Information Systems

To model demand, data and supporting systems are required. The data gathering and elaboration of the systems represent the starting point to implement and monitor the resulting real-time decisions. In this case information technology enables companies to operationalize RM science.

The services industry, and more specifically the airline industry, is an excellent case on data management and information technology and system support. The pricing and distribution processes of this industry were widely automated with the implementation of GDSs starting from the 1960's. Therefore it is one of the earliest industries to move almost entirely to electronic selling and distribution already decades before the advent of e-commerce. Also the manufacturing industry has today the same potential to leverage data availability and information systems, even if those can differ in terms of use and level of maturity between companies.

2.6.9 Corporate Culture and Management Support

Last but not least a "soft" prerequisite linked to corporate culture and more broadly to change management aspects and the management support linked to it is considered an important aspect by researchers. RM demands a management approach that is receptive to science and technology. The culture of the industry or of a specific company positively conditions the implementation success of RM, especially when inclined to accept innovations and deterministic decision mechanisms.

If the implementation of RM is additionally supported by top-level sponsorship, success probability increases even further. This holds for any kind of company.

Firms that exhibit all or most of the above characteristics can expect significant gains deriving from the application of RM practices.

2.7 Price and Capacity Management

Of the various RM instruments available (for an overview see Klein and Steinhardt 2008; Talluri and van Ryzin 2004), we only wish to consider the price and quantity management that is generally suitable for the manufacturing industry and specifically suitable for the order-based process industry (Klein 2001).

Price and quantity management is divided into revenue-based and quantity-based management (Klein and Steinhardt 2008). With respect to quantity-based management, total capacity is divided into partial capacity with different prices. In the airline industry, the partial capacities correspond to the quotas for individual booking classes, while in MTO manufacturing, these partial capacities are reserved for specific order types, such as large-volume orders with a later delivery date. A range of partial industry-specific planning approaches are stipulated for the distribution of capacities in the literature available (see for example Talluri and van Ryzin 2004). Demand will be assumed if the explicitly or implicitly demanded partial capacity is still available in sufficient quantities.

With respect to revenue-based management, the price offered by the demanding party is compared with an internal reference price determined on the basis of opportunity cost. If the price offered exceeds the reference price then the demand is accepted, otherwise it is rejected. Revenue-based management enables a negotiation process with the customer in which different (reference) prices are determined subject to different delivery dates (see for example Keskinocak and Tayur 2004).

Quantity-based management is also referred to in this paper as capacity management and/or capacity control, and revenue-based management is also referred to as price management and/or price control.[6]

Price and capacity management is deemed to be in place if both control elements are used parallel to each other, as partial capacities are reserved for specific order types and decisions are made on the basis of reference prices regarding the acceptance of orders, for example.

2.8 Profit Impact of RM

Since its introduction, RM has been used throughout the airline industry and has made a substantial contribution to airlines' profit. By most estimates, the revenues gains from the implementation of RM are roughly comparable to many airlines' total profitability in a good year, i.e. about 4–6 % of revenues.[7]

[6] The term "pricing" is also used at times in the preliminary study interviews presented in Sect. 2.4. However a distinction must be made between the latter and the concept of "dynamic pricing" (see for example Klein and Steinhardt 2008).

[7] Skeptic voices point to Southwest Airlines as a counterexample. However, Southwest Airlines does use RM systems. Because its tariff structure is less complex than most other airlines the use of RM is less obvious to consumers and casual observers.

The increase of revenue and earnings, credited to RM by US Airways and Delta Airlines, was $500 and $300 million respectively (Boyd 1998). American Airlines indicated increased revenues of approximately $1.4 billion over a 3-year period deriving from effective employment of a RMS (Smith et al. 1992). RM also helped Marriott Hotels gain $100 million additional annual revenues (Cross 1997). RM can also contribute substantially to cost savings and revenue maximisation in the airline industry while helping maintain quality (Elliott 2003). Success cases of RM application in service industries have been reported in Europe as well: As a result of using RM, Lufthansa was able to generate additional profits of 105 million euros in 2005 (see Klophaus and Pölt 2007).

The successful application in terms of revenue and profit impact of RM in the manufacturing industry has been assessed in Smith et al. (1992), Welch (2003) and AMR Research (2010). However, since research in the manufacturing industries is still in its infancy (Chiang et al. 2007), very few companies experiencing RM successes have been explicitly quoted in the literature. We are aware of only two. One is ThyssenKrupp VDM, a leading global producer of high-performance nickel and cobalt alloys as well as special stainless steels. The employment of RM generated gains in contribution margin and quantity of up to 13 and 8 %, respectively (Hintsches et al. 2009). The second is Ford Motor Company in the automotive sector: Ford developed an RM system (RMS) in 1995 and in 1998 it was in use in 5 out of 18 U.S. sales regions. While those regions using RM exceeded their profits by $1 billion, the other 13 regions were short of their target by $250 million (Blumenthal et al. 2008).

2.9 Fairness Within RM

One of the key elements in the successful application of RM is dynamic pricing. The perception of trust as well as fairness and its effect on variable pricing decisions, however, is an undervalued and under-researched field (McMahon-Beattie et al. 2002).

Customers paying more for a product or service that is similar or perceived as equal may consider the company selling the same product or providing the same service at a lower price at a different time or to a different group of customers as unfair.

When solely focusing on short term benefits RM runs the risk of alienating customers regarding RM as an unfair practice and thus puts the long-term profit maximization at stake. Managing the perceived fairness of RM is therefore a key to its implementation success.

2.9.1 Key Elements of Fairness

When discussing fairness, researchers use the concept of "reference transaction", thus referring to how customers think a transaction should be conducted and to how much a given product or service should cost in the customers' opinion. In order to identify the price that is perceived as fair customers use "reference prices" that reflect e.g. market or posted prices or past experience with the company (Kahneman et al. 1986).

According to researchers, customers believe that the value to the firm should equal the value to the customer. If that relationship becomes unbalanced by increasing the value to the firm or decreasing the value to the customer, the customer may view subsequent transactions as unfair. In this context the principle of "dual entitlement" holds that most customers believe that they are entitled to a reasonable price and that firms are entitled to a reasonable profit (Kahneman et al. 1986).

From the above principle of "dual entitlement" three hypotheses emerge: (1) Customers believe that raising the price to maintain profits is fair. If costs increase, customers consider it reasonable for the price of the product or service to increase; (2) customers feel that raising the price to increase profits is unfair; and (3) If costs decrease, customers believe that it is reasonable for the company to maintain the same price, e.g. because the customers are paying what they think they should, or because they believe management should reap the rewards of its cost-cutting efforts (Kimes 1994).

2.9.2 Fairness Within the Service Industry

The application of RM in the service industry has a long track record and customers have accepted to pay different prices for the same service, even accepting restrictions for specific fares e.g. when flying. As RM is gaining in popularity in several service industries, the question of how customers react to RM remains relatively unexplored, apart from the airline and hotel industries, where RM can increase revenue without affecting customer satisfaction (Kimes 1994).

In fact, recent studies in the hotel industry have shown that variable pricing practices do not result in lower perception of fairness among customers. Moreover, in the cases in which information on the room pricing practices of the hotel was offered to customers at the same time of reservation, unconstrained acceptance of RM was registered (Choi and Mattila 2004).

Perceived fairness in the leisure industry, e.g. in the golf industry, represents another area of research that has provided valuable insights. The study results show that golfers perceive arrival duration control practices in the form of reservation fees or no-show fees as fair. Additionally, it has been found that golfers perceive demand-based pricing in the form of coupons (two for the price of one), time-of-day

and reduced tee time intervals as fair. Conversely, time-of-booking prices are rated as unfair (Kimes and Wirtz 2003a, b).

2.9.3 Fairness Within the Process Industry

In the process industry customers may pay different prices depending on different criteria like the set due date and processing time. However, empirical studies on perceived fairness related to RM practices in the process industry are extremely rare.

2.9.4 Price Increase Strategies

Researchers draw conclusions from the perception of fairness in relation to RM. Generally customers view justified price differences as fair, but unjustified price increases as unfair. If a customer thinks that the transaction is only different from the reference transaction in price, she may believe that the firm is receiving more than its reference profit and is thus behaving unfairly (Kimes 1994).

Either of the following four options can be chosen to handle price increases without hurting customers' perceived price fairness: (1) Increasing the reference price by e.g. the full-fare rate: most customers receive some discount, and if informed of the discount, may consider themselves lucky; (2) Attaching additional services or products to the service sold at an increased price, thus increasing the perceived value to the customer; (3) Bundling the product or service in order to obscure the price; (4) Attaching restrictions to discounted prices so that higher prices with fewer restrictions seem fair by comparison (Kimes 1994).