# Dynamic Pricing and Its Forming Factors

**Indre Deksnyte**
Faculty of Economics and Management
Vytautas Magnus University
Kaunas, Lithuania

**Prof. Zigmas Lydeka**
Faculty of Economics and Management
Vytautas Magnus University
Kaunas, Lithuania

## Abstract

*The determination of the proper price still remains a complex task that requires organization's knowledge not only about its operation expenditures but also about its possibilities to foresee products demand and their value with regard to a consumer. Thanks to the advance of Internet technologies and sales in electronic environment, the information about customers has become more accessible what has determined greater interest in dynamic pricing researches and their application in different services and industry sectors. This paper provides an overview of dynamic pricing concept, its terminology problems and finally the main dynamic pricing forming factors.*

**Key words:** dynamic pricing, revenue management, e-commerce, dynamic pricing forming factors

### *1. The conception of dynamic pricing and its terminology problems*

Looking from a historical perspective, dynamic pricing and its application became interesting research part in 1970-s when appeared research papers of Rothstein (1971) and Littlewood (1972), which analyzed the possibilities of the application of dynamic pricing in airline and hotel sectors. When in 1978 the Airline Deregulation Act passed by the USA congress declared that within the forthcoming four years airline sector would not be regulated, all that encouraged the development of dynamic pricing researches in both scientific and practical field.

Later in 1980-90-s dynamic pricing researches spread in such spheres as, *car rental* (Caroll, Grimes, 1995; Geraghty, Johnson, 1997 et al.) *communication* (Strasser, 1996; Ciancimino et al., 1999 et al.), *cruises* (Ladany, Arbel, 1991; Gallego, van Ryzin, 1994 et al.) *hotels* (Hayes, Miller, 2011 et al.) and finally in 1990-s – *retail*, *production* (Subrahmanyan, Shoemaker, 1996; Bitran, Monschein 1997 et al.), *telecommunications, electricity supply* (Nair, Bapna, 2001) (see figure 1).

The researches of dynamic pricing (hereafter DP) have been developed for the past 40 years; the definition has been developing similarly. All this time DP has been analyzed and tried to be defined in various research areas: *management* (Kalish, 1983; Dehbar, Oren, 1985; Braden, Oren, 1994; Desiraju, Shugan, 1999; Gallego, van Ryzin, 1994), *economics* (Krugman, Phlips 1983, Baker, 1994; Grewal, Compeau, 1999; Huang, 2005; Aguirregabiria, 1999; Zettelmeyer, Scott Morton, Silva-Risso, 2003; Chan, Hall, Rust, 2004; Sweeting, 2008; Copeland, Dunn, Hall, 2009), *operations control processes researchers* (Belobaba, 1987; Williams, 1999; Popescu, Wu, 2007; Zhang, Cooper, 2005; Ziya, Ayhan, Foley, 2004; Ahn, Gumus, Kaminsky, 2007 et al.). The scientists conducted many empirical researches, which aimed to reveal how to model DP in different spheres of services/industries, which factors have a significant effect on the DP formation, what is the benefit of DP application; and finally the researches tried to define DP and its typology.

However to define DP exactly and solidly is still a complex task for several reasons, the most important of which are the following: different interpretation of this conception by the representatives of various scientific spheres, the orientation of the DP researchers towards different academic branches.

One of the first and mostly cited definitions of dynamic pricing was given by the company "American Airlines" which stated that DP is a tool to maximize revenue "selling a suitable product, to a suitable client, for a suitable price" (Weatherford, Bodily, 1992); later this definition was supplemented with the words "in suitable time". Regardless of this widespread definition other researchers of dynamic pricing (Jones 1999, Weatherford, Bodily 1995) stated that there is no any competent definition of dynamic pricing which could be introduced as a standard in research literature.

That induced constructive articles of Belobaba, which forced to include dynamic pricing into operation management researches. However, within the context of operation management researches the understanding of DP was restricted only to resource planning and allocation, given a certain set of prices (Desiraju, Shugan, 1999). These researches did not estimate demand – demand profile is distinguished from both resource allocation and company's pricing policy. (Talluri, van Ryzin, 2004). Conversely the representatives of other spheres when researching the principles of DP formation maintained that demand and consumer behavior are nearly concerned with the purpose of dynamic pricing formation to control revenue (Fleischmann et al., 2004).

For a long time in scientific researches DP were identified with revenue management. So, using DP and revenue management terms scientific literature does not contain strict boundary between conceptions that define these terms. This range of problems also reflected in business practice of Cary (2004) who stated in his article: "...DP and revenue management act differently in the USA airline area. DP focuses attention on rivals' actions and the reaction of product supply and demand. Revenue management focuses attention only on models and trends, which are designed on the ground of demand data. Similarly Desiraju and Shugan (1999) compared DP to revenue management and regarded them as substantially different practices. The authors of the thesis emphasizes that these conceptions should not be identified because DP researches include the determination of optimum product price evaluating supply/demand behavior and the assessment of that reflecting indicators.

Within a context of economic researches in DP is often related to price discrimination: DP is understood as an attempt of a seller to force a customer to pay the highest price he is ready to spend. According to Krugman (2000), dynamic pricing is a new practice of old price discrimination. According to him, modern technologies made dynamic pricing useful not only for different areas of industry/services but also for economics. In this context it is worth to mentioning Philips (1983). He summarizes a typical attitude of economist towards price discrimination and states that DP is necessary in order to allocate resources in the optimum way in real-life situations. This statement may sound strange because usual economic analysis states that in the competitive market price is equal to marginal costs and that all that maximizes welfare. However, based on modern true-life situations many sectors of industry such as pharmacy, telecommunications and information technologies experience high fixed costs and less marginal costs. In case of such situation, when prices are set according to marginal costs level, it would be impossible to retrieve initial investment, so in this case DP is assessed positively. Thus, DP definition has a tendency to show which academic field governs the knowledge of this topic.

As it was mentioned at the beginning of DP researches its conception was clearly considered the part of operational management researches (Williams, 1999). In 1999 the authors of the scientific article in the magazine "Operational Research Society" Yeoman et al. (1999) claimed "universally accepted wide definition of DP" sounds like "the allocation of resources and inventory to a suitable client for a suitable price in order to maximize revenue and profitability". Over the last years demand behavior has also been included into DP researches (Feng and Gallego 2000), whereas the absence of standard DP definition, declared by Jones (1999) et al, allowed strain to settle among the disciplines that research this area. Despite the influence of other disciplines operational research still clearly dominates in the literature concerning revenue management. Although today OM researchers recognize that product demand is an integral part of DP researches (Boyd and Bilegan 2003), the definitions are still concentrated on supply as evidenced by Kimes and Thompson's (2004) definition: "Dynamic pricing is the form of resources management where supply is controlled manipulating useful life and price". This is not consistent to the definition of Fleischmann, Hall, Pyke (2004): "Dynamic pricing is related to price-fixing for perishable resources taking into account demand so that to maximize revenue or profit".

In this context it is worth mentioning that the majority of scientists (Williams, 1999; Ziya, Ayhan, Foley, 2004; Ahn, Gumus, Kaminsky, 2007) do not define DP in their papers; they pay more attention to DP modeling, observation of results and try to convey DP conception showing the benefit of DP application.

Thus, the contribution to DP knowledge depended on how DP problem was defined. As consequence it would be possible to classify DP definitions according to its treatment in different fields of science (see figure 2). In common, definitions of DP are crisply defined as a means related to the fixing of optimal price in order to maximize revenue. Such definitions are the most common. The second type is definitions oriented towards demand where the greatest attention is paid to demand parameters and their contribution to DP formation. The third type is the definitions oriented towards supply, which are the most common in the area of operation researches. Finally, the definitions oriented towards demand/supply balance, which emphasize that price maximization can be achieved DP controlling demand/supply disbalance.

## *2. Dynamic pricing forming factors*

Research literature gives a wide variety of dynamic pricing forming factors. Researchers solidly agree that there is no one solid generally accepted classification of the factors which form dynamic pricing as well as there is no their solidly reasoned interaction. It mentions only assumptions on the ground of which it is possible to distinguish and systematize dynamic pricing forming factors.

The researches, taking into account the multidimensionality of DP conception, it is recognized that one or several factors do not reflect the range of problems of DP and its fully accomplished modeling possibilities, so the researchers distinguish more and more different DP factors which can be grouped. The main factors, which are often named DP researches, are the following. Now let's discuss the main DP forming factors in more details.

### 2.1.Customer behavior and characteristics

According to Talluri, van Ryzin (2004) one of the most important factors modeling DP is the level of customer's knowledge. When analyzing DP scientific literature often supposes that customers are *myopic customers* – the group of customers who makes a purchase provided that the suggested price is less than they want to pay. Myopic customers do not need to accept complex buying strategy, for example, to refuse purchase in the hope of fewer prices in future. They just buy at once when product's price comes down lower than they want to pay (Talluri, van Ryzin 2004). Conversely, *strategic* customers optimize their buying behavior responding to the pricing strategy applied by organization. Although DP modeling is more realistic, assuming that there are strategic customers in the market, in this case price imitates the game of strategy between an organization and a customer and aggravates the evaluation and analysis of optimal pricing strategy (Aviv and Pazgal 2008). Thus, DP modeling with regard to myopic customers is discussed and analyzed in scientific literature more often. It is necessary to recognize that in most cases customers make spontaneous decisions, and all that eliminates their strategic behavior. Besides, according to the author the lack of time and information do not allow customer to behave strategically in the market. However, the more expensive and durable is a purchase the more important is to model the behavior of a strategic customer (for example when purchasing luxury fashionable goods). Talluri, van Ryzin (2004) emphasize that when modeling DP predictive models, which are supported by the statistic indicators of customers' past, in some specified sense reflect the influence of customer strategic behavior. According to the researches, if very sensitive to price myopic customers tend to postpone their purchases till the end-of-season sale, the sensitivity of these later periods to price changes will seem much bigger than it was within previous periods.

Aviv, Pazgal (2008) introduce cases when modeling product demand provided that customers are myopic, appears the risk of "bad balance". In accordance with authors' example: by virtue of past statistic data the model which operates on the ground of myopic customers confirms that it is advisable to reduce prices significantly at the end of season because in his estimate demand is very sensitive to price during this period. However, all that can be because customers knew that it was not worth buying at that time because prices would be reduced at the end of the season or during holidays. If an organization has always held firm to such pricing strategy, and the customers have been sure that this strategy will not be ignored in future, model suggestion to reduce prices is false because the evaluation used the model made on the ground of myopic customers. However, despite all these disadvantages the author states that DP, which is modeled on the ground of myopic customers, is widely used in practice and gives us important and valuable information with regard to forecasting in order to maximize organization's revenue.

Other important customer's characteristic very significant for DP formation distinguished by Talluri, van Ryzin (2004) is whether the population of potential customers is finite or endless. In case of *endless* population the number of customers and their willingness to pay for a purchase are not influenced by past demand data. That is also defined as the assumption of nondurable goods (for example, bread), when a customer who has just bought desirables goods at once becomes the part of the population of potential customers. In case of *finite* population, if one customer from the population buys goods, other purchases are expected only from the rest members of the population. In economics theory all that is defined as the assumption of durable goods, because a customer who purchases durable goods (for example, a car) eliminates himself from the list of the potential customers of the population. Which of these criteria is the most suitable depends on the circumstances of DP modeling. The main factors choosing one or another circumstance are goods type (durable or nondurable) and the number of potential customers.

### 2.2. Fair prices

The majority of researchers (Campbell, 1999; Bolton et al., 2006; Haws, Bearden, 2004 et al.) detect links between fair prices applied by organization and DP existence. Price fairness is defined as „consumer's evaluation and understanding whether the difference between seller's and other party's prices is reasonable, acceptable or justifiable" (Maital, 2004; McFadden, 1999). The perception of price unfairness causes consumers' dissatisfaction, the spread of negative information, which damage sellers' reputation and encourage trust in them (Campbell, 1999). So, in their article Bolton et al. (2006) ask researchers to pay more attention to price fairness issues which would help to cope with negative consumers' reactions caused by dynamic pricing. Haws, Bearden (2004) indicated, and the author agrees with this statement, that consumers' perception that organization's prices are fair in their regard is the most important condition which is necessary to hold in order dynamic pricing to operate effectively.

In this context it is worth mentioning that in scientific literature consumers' response to unfair prices is explained on the ground of the following theories: distributive justice theory, equity theory and dual entitlement principle). Distributive justice theory focuses its attention on the perception how fairly resources and rewards are allocated. Previous researches conducted on the ground of this theory define fair justice distribution as "reward distribution according to individual contributions to goods-money relationship" and state that people obtain the perception of fairness when all parties involved in goods-money relationship get adequate reward. In regard to price fairness this theory postulate that a consumer realizes price fairness when he pay the same price as other consumers for the same product or service (Bolton, 2006).

Equity theory states that people realize the fairness (justice) of transactions comparing the ratio of their contribution to certain transactions with results. In support of this theory researchers argue that the perception of transactions unfairness make people feel dissatisfaction, and thus they will try to restore justice by means of their behavior or cognitively (Haws, Bearden, 2004).

Finally, according to dual entitlement principle, Kahneman (2000) states that the perception of fairness is determined (influenced) by orientation transactions and truck context. The parties of truck believe that they have a right to orientation price and orientation profit. Thus, if any party does not gait its right the relationships are understood as unfair.

### 2.3. Market structure

One more very important factor modeling DP is the level of competition an organization faces. The majority of DP models are active under the conditions of monopoly when the assumption is made that product demand depends only on itself, but not on competitors' prices. Thus, these models do not clearly take into consideration competitive response in case of price change. DP applicability in case of monopoly is discussed in the papers of Chatwin (2000), Feng and Xiao (2000), Gallego, van Ryzin (1994, 1997), Lin (2004), Zhao and Zheng (2000). In case of oligopoly which estimates a response to competitors' price changes, so DP modeling causes certain difficulties such as models complexity and limited possibilities to collect competitor's statistical data. However, properly projected DP models operating under the conditions of oligopoly can provide precious knowledge experimenting with DP application possibilities (Cachon and Zipkin (1999), Hopp and Xu (2006), Lippman and McCardle (1997), Mahajan and van Ryzin (2001), Netessine and Rudi (2003).

In case of perfect competition the products of each organization occupy a small share of market; each organization sells identical goods and therefore cannot affect market prices. So, each company can basically sell as much as it wants at a price not higher than market price, i.e. an organization has no any impact on prices. Although perfect competition is a very important research object in economics, it is rarely analyzed in DP researches.

### 2.4. Product demand

Gallego, van Ryzin (1994), Feng, Gallego (1995) emphasize the importance of demand definiteness modeling DP. According to the author product demand is one of the most important factors forming DP. In DP researches demand is often modeled as exogenous stochastic process with known probability distribution. However, such models have some restrictions 1) they are fully dependent on comprehensive demand parameters while pricing products; 2) they do not include any repeated demand evaluation devices, when in the event of the appearance of more information that determines product demand, product prices are repeatedly reconsidered. As a consequence in their researches scientists resolve the problems of undefined demand in increasing frequency. The literature mentions two main sources of demand indefiniteness: indefiniteness concerning „product and consumers' qualities" and indefiniteness concerning „unpredictable factors", such as weather. Given an unknown product demand, in the course of time a seller tries to measure and evaluate it. In scientific literature this process is called *demand learning.*

In this context it is worth to mention some important DP researches, which evaluate demand learning and its importance for DP modeling. In their papers Carvalho, Puterman (2004), Dada, Petruzzi (2002) discuss the problem of dynamic pricing when only the form of demand function is known, but not parameters which are renewed in the course of time using Kalman's filters. Aviv, Pazgal (2002) show in their works that there is compatibility between low price which causes loss of revenue and high price which reduces purchase probability, whereas demand is undefined for a long time. Boyd, Lobo (2003) justify the differences of market prices based on rational learning behavior of the firms. The authors show a case of monopoly with stochastic linear demand whose parameters are also unknown. Iyer and Bergen (2007) study the systems of „quick reaction", in which retailers are forced to get as much information as possible about prospective demand because of shortened time necessary to execute an order of new products. Bitran and Wadhwa (1996) in their works also analyze the influence of demand learning process on DP formation. The authors solve the unsteady problems of shopping and reserve prices allocation.

### 2.5. The perception of product value

Customers often postpone purchases with a view to get better offer in future. However, there can be other reasons that determine specific time of purchase. Especially when customers are not sure how they evaluate a certain product, they make a decision to wait until they get more necessary information (Xie, Shugan 2001). During DP researches scientists Koenigsberg, Muller, Vicassim (2006), Carvalho, Puterman (2004), Dada, Petruzzi (2002) analyzed customer behavior in case of product value indefiniteness. Gallego, Sahin (2006) study selling options for clients who face product value indefiniteness. Choice transaction ($x$, $p$) is originally priced by value $p$ and that gives it a right to require price x, after a product is evaluated. The authors give two cases of choice transactions: (0, $p1$) options are of nonrecoverable price, paid before realizing value, and ($p2$, 0) the case – of current price, goods are priced when a consumer identifies goods value. Yu, Kapuscinski, Ahn (2005) analyzed stochastic, but independent cases of value definiteness. Koenigsberg, Muller, Vicassim (2006) represent the model of two classes, two periods, where market size and composition are fixed, whereas customers face uncertainty fixing product value. The authors additionally explore a possibility to offer last minute discount at the end of the second period. They draw a conclusion that it is useful only when customers do not know whether these suggestions will be offered in future.

Dada, Petruzzi (2002), Yu, Kapuscinski, Ahn (2005) do not forget to include perceptible quality into DP researches, *as* an important variable directly related to product price. According to them customers use price both as an indicator of perceptible product quality and as an indicator of perceptible costs which will be incurred during the purchase of a product. Conducted researches allow drawing a conclusion that the perception of value is directly related to customers' preference and choice, i.e. the higher value perception is, the bigger a wish to buy or product preference is.

### 2.6. The Seasonality

Researchers trace that prices change and seasonal fluctuations influence some goods more than others. The sector of style-and-fashion goods can be an example where at the end of the season old clothes collections are sold out at a low price. Besides, in food industry some goods are sold at a discount during holidays (Chevalier et al. (2003)). The influence of seasonality on prices can be noticed within a week, for example, discounts for alcohol drinks are often made on Fridays. All these examples lead to the same conclusion: goods prices are reduced during the peak of high demand. However, in their work, which is mostly related to price change frequency and extent throughout the year, Bils and Klenow (2004) state that regardless of high demand periods it also depends on the type of goods.

Alvarez et al. (2010) studies price changes analyzing the selling of very different types of goods within the space of 9 years. The author made two conclusions: with regard to price changes there is no difference between durable and nondurable goods; the bigger (smaller) degree of competition is, the bigger (smaller) price changes frequency. According to Alvarez et al. (2010), a competition type means more than a product type as far as is concerned price changes and the impact of seasonality on prices.

According to Warner and Barsky (1995) demand is more flexible (quickly adaptive) during the peak of demand, what brings them to a conclusion that optimal mark-ups are anti-cyclic. When customers look for goods during the period of high demand, they become very sensitive to price when demand is high, because they know much more about substitute goods prices than during the periods of small demand. When customer's price sensitivity increases firms reduce prices holding down market segment. The research results of Chevalier et al. (2003) show that during the periods of higher demand: prices are lower, the effect of substitutes is bigger, profitability is smaller because prices decrease, whereas marginal costs remain unchanged; heavier expenses for the advertising of seasonal goods.

## *3. Conclusion*

The scientists conducted many empirical researches, which aimed to reveal how to model DP in different spheres of services/industries, which factors have a significant effect on the DP formation, what is the benefit of DP application; and finally the researches tried to define DP and its typology. However to define DP exactly and solidly is still a complex task for several reasons, the most important of which are the following: different interpretation of this conception by the representatives of various scientific spheres, the orientation of the DP researchers towards different academic branches.

The researches, taking into account the multidimensionality of DP conception, it is recognized that one or several factors do not reflect the range of problems of DP and its fully accomplished modeling possibilities, so the researchers distinguish more and more different DP forming factors. These factors are the main criteria, how DP should be modeled and adapted to the business environment.

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**Figure 1: Dynamic pricing development**

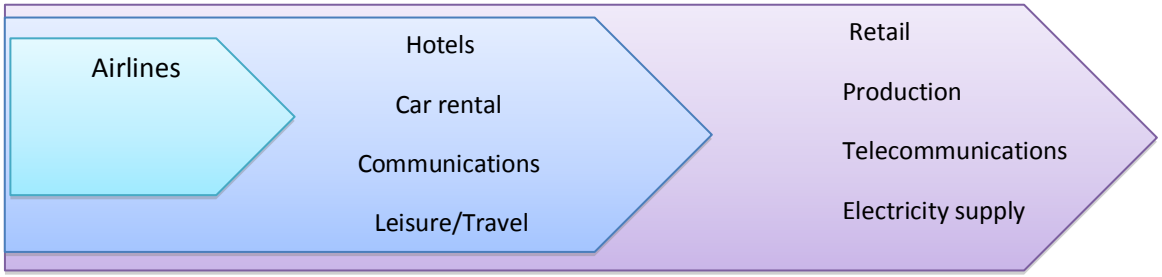


**Figure 2: The classification of dynamic pricing definition**

| Definition type | Features | Researchers |
|---|---|---|
| **Appellative definitions** | DP is defined as a tool maximizing the company's revenue and/or profit. | Weatherford, Bodily, 1992<br>Huang, 2005;<br>Aguirregabiria, 1999;<br>Yeoman ir kt., 1999 and more |
| **Focusing on demand** | Definitions, which focus on product/service demand, DP modeled taking into account the demand parameters. | Feng, Gallego, 2000;<br>Radjou, 2003;<br>Fleischmann, Hall, Pyke, 2004 and more |
| **Focusing on supply** | DP is defined as resource management tool/form. | Yeoman, 1999;<br>Kimes, Thompson, 2004 and more |
| **Focusing on balance of demand/supply** | DP perceived as the best price reflecting supply/demand balance. | Braden, Oren, 1994;<br>Desiraju, Shugan,1999;<br>Gallego, van Ryzin, 1994 and more |