

Chapter 5

Pricing Foundations and Implications on Web Service Pricing

5.1 Pricing Principles in General

One of the key building parts of a market is its market mechanism. This mechanism encloses the rules for allocation and pricing and thus regulates and, in some cases, enforces the procedures of trading on a specific market. In general, both issues of allocation and pricing are intrinsically tied to one another. [Neumann et al. \(2007\)](#) and [Buyya et al. \(2008\)](#) treat online trading platforms. For example, such as Grid and Cloud service exchanges. Yet, since allocation procedures are often directly connected to technical conditions, in the following the focus is mostly on the pricing mechanisms that are used in today's markets. Basically, one can distinguish between static, flexible, and dynamic pricing, which can be further subdivided into concrete pricing schemes.

5.1.1 Static Pricing

Static pricing can be regarded to be the simplest form of pricing mechanisms. The price of a unit of a good is constant and is also referred to as linear (or uniform) because the amount of money that is paid by the customer is linearly related to the volume of the good purchased by this same customer. Naturally, the price depends on the costs for the provision of the good. These costs are usually made up of fixed costs, that is, the initial investment to achieve the capability to produce the good and which costs are independent of the volume produced eventually, as well as variable costs that are directly linked to the quantity produced. The ratio between fixed and variable costs can vary a lot depending on the kind of product. While for simple physical goods sunk fixed costs may be low and main costs occur during the production process itself. [Shapiro and Varian \(1999\)](#) note that for information goods the contrary holds, that is, the sunk fixed costs to initially

produce an information good are much larger than the costs for reproducing this information.

Even though in a competitive environment costs are the main factor for the pricing decision of a single firm, the demand for the good plays also a role which is the more important from the perspective of the single supplier the more concentrated the market is. The mark-up (the difference between the price and the costs) will be higher the more market power the supplier has and the more inelastic is the demand the supplier faces. In particular, the price–cost margin of a monopolistic firm is inversely related to the price elasticity of demand (Tirole 1988; Gravelle and Rees 1993). This is illustrated in Fig. 5.1 where a monopolist with decreasing returns to scale (the average cost curve is decreasing and lies below the marginal cost curve) sets the profit-maximizing price for a good. The optimal price P^* is found at the (inverse) demand curve ($P(q)$) for a quantity q^* which equalizes marginal revenue MR and marginal costs MC . The realized profit is the area enclosed by q^* and the difference between the price P^* and average costs $C = AC(q^*)$. One can easily verify that this area would be larger for a steeper (more inelastic) inverse demand curve.

Even if the firm is able to set as high a price as the monopoly price from the consumers, the static pricing strategy is usually considered to be less profitable and not promising to achieve comparably high revenues as with advanced pricing schemes.

This notion is based on the fact that static pricing does not take into account other information that probably is available like, for example, differences in customers’ preferences. The flexible pricing schemes that will be discussed in the next section were designed to make use of such information in order to extract more surplus from the consumers.

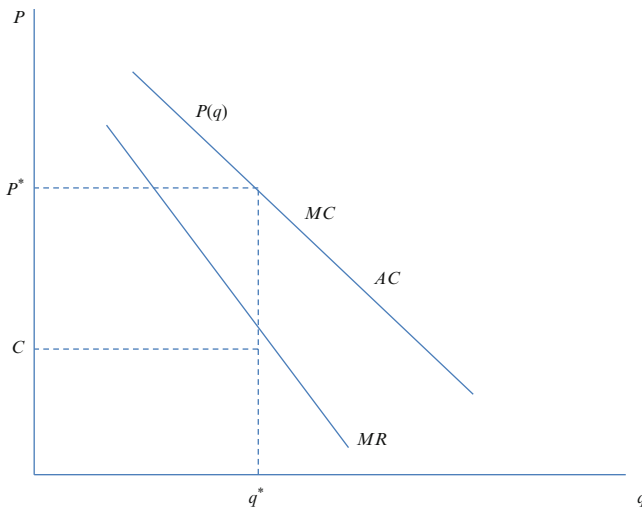


Fig. 5.1 Static pricing by a monopolistic firm (see Gravelle and Rees (1993), p. 272)

5.1.2 Flexible Pricing

Flexible pricing mechanisms are designed to take into account specific customers' preferences and make use of them in order to achieve higher sales and revenues. Products that are designed to meet customers' requirements (up to a certain degree) enable the customers to choose that product from a variety of versions which fits their needs best. For the supplier, the probability of selling a certain product (or product version) rises, since, given a larger product set to choose from, the customer may acquire a product he would otherwise not purchase at all (as, for a given price, the product's properties, including the price, differ too much from the customer's preferences). Speaking of customer's preferences may refer to several aspects, such as the quality of the product (or, for instance, the quality of service of a Web service) or product related features. Differences in the preferences of customers allow firms to increase their profits by product differentiation and price discrimination. However, in order to present the matter in a compact fashion, this chapter focuses on the customers' willingness to pay for different product offers. Firms may then engage in forms of either price discrimination or product differentiation with varying prices in order to increase their profits.

Flexible pricing is realized by price discrimination.¹ The method of price discrimination to be employed depends on the available information about customers that are expected for the specific product as well as on the possibilities of arbitrage in the market(s). Arbitrage between customers is based on transferability of the product, which applies only to a limited degree for services by their nature. The more detailed the available information is and the less trading activities customers can engage in, the better can the market be skimmed by the provider. Price discrimination is structured into three different degrees.

In this section, the basic ideas of price discrimination and several mechanisms that implement these are outlined. A general overview is given by [Tirole \(1988\)](#). For a more detailed discussion, please refer to [Shapiro and Varian \(1999\)](#); [Varian \(1997\)](#). The figures in this section also follow their style.

5.1.2.1 Personalized Pricing

First degree price discrimination is applied in the case that there is perfect information about each customer's willingness to pay. A producer (or service provider) will offer the product (or service, respectively) at a price that is equal to or marginally lower than the respective willingness to pay of the consumer under the assumption that there is no collusion among customers. Thus, the perfect information available to the provider is completely exploited and maximizes the provider's revenue. The difference in profits between simple static pricing and personalized pricing

¹Also: price differentiation.

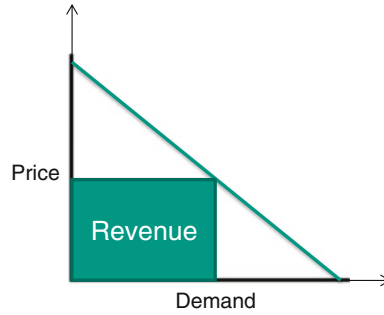


Fig. 5.2 Provider's revenue with static pricing

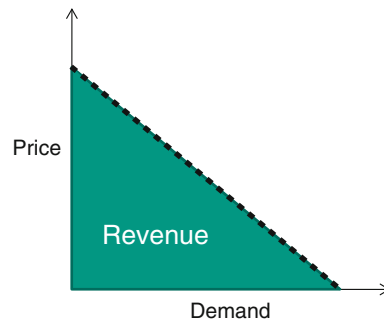


Fig. 5.3 Provider's revenue with personalized pricing

is illustrated in Figs. 5.2 and 5.3. While for static pricing with a fixed price p all customers with a willingness to pay higher than p buy the product at this price, customers with a lower willingness to pay do not purchase the product at all. This means potential losses on both sides, as can be seen in Fig. 5.2. This drawback is eliminated by personalized pricing, as seen in Fig. 5.3. However, personalized pricing is a merely theoretical pricing scheme and denotes the ideal case (from the point of view of the provider). Since in real scenarios it is extremely challenging for a provider to determine each individual's willingness to pay, such a scheme can hardly be enforced and is, therefore, impractical. This approach becomes even more complicated when one considers that in many cases not even the consumers can estimate their own willingness to pay. The pricing mechanisms that are introduced in the following section serve to achieve an applicable solution while sacrificing the theoretical profit-optimizing solution.

5.1.2.2 Self-Selection: Versioning, Bundling, and Amount-Based Pricing

Price discrimination of second degree is a practically feasible approach that provides the seller with a means to achieve higher revenues as compared to static pricing by

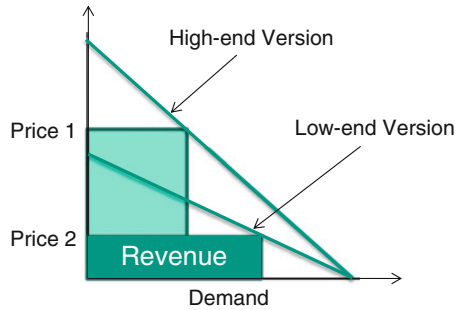


Fig. 5.4 Provider's revenue with versioning

offering his product in different ways. The pricing schemes discussed in this section are versioning, bundling, and amount-based pricing. As these pricing schemes usually leave the customer with a choice to select from several varieties bundles of the product, price discrimination of second degree is also called *self-selection*.

When applying versioning, a provider offers a product in different versions at different prices, for example, a high-end version at a high price and a low-end version at a low price. While the offer in Fig. 5.2 could be seen as a single version only, in Fig. 5.4 the provision of two versions of a product, high-end and low-end, is illustrated exemplarily. In the versioning scenario, customers with a lower willingness to pay will acquire the latter, while customers with a higher willingness to pay or the necessity for specific features will buy the high-end version. For the customer preferring the high-end version, the price savings from the low-end version are not sufficient to offset the missing product features. Versioning of a product is usually facilitated by a variation in price, quality of the product, or specific features. A simple example would be an internet service provider, offering several products (i.e., access to the internet) that differ in speed and the provided support.

The challenge of offering different versions of one product is to determine what kind of versions to offer at which price. At first glance, this problem might seem similar to the personalized pricing approach. Nevertheless, versioning is much more applicable as it does not require to specify prices according to individuals' willingness to pay but rather prices for a limited amount of product versions. Since the focus of versioning is on the product itself, market surveys can usually be used to estimate the appropriate version and price combinations. Even though in many cases it still remains a challenging task to design the optimal product versions and their according prices to achieve the maximal revenue.

While versioning sets different prices for different versions of one product in order to approximate the optimal revenue rates of personal pricing, bundling aims to achieve that by offering several products in one package. Therefore, the customers may choose whether to acquire products separately or in a bundle. This approach is particularly useful, when it is assumed that the customers have

heterogenous willingness to pay for each product. The following examples illustrate this.²

Example 5.1. There are two different products p_1 and p_2 and two customers c_1 and c_2 , with heterogeneous willingness to pay for each product. While c_1 is willing to pay 8 and 4 monetary units for p_1 and p_2 , respectively, customer c_2 has the opposite willingness to pay vector, that is, 4 and 8 monetary units for products p_1 and p_2 . In case the marginal costs for the product provisioning are assumed to be zero, it can be shown that for a (monopolistic) provider it is optimal to set the prices for each product to 8, and to charge 12 for the bundle. In this way, the bundle always turns out to be profitable, as both customers are willing to acquire the bundle, rendering 24 monetary units of profit. If p_1 and p_2 would be offered separately only, c_1 would only buy p_1 , and c_2 only p_2 , yielding a profit of only 16 monetary units.

The reason for the profitable usage of bundling is that it effectively reduces the dispersion of the customers' willingness to pay. One can distinguish between two strategies, pure and mixed bundling. Pure bundling means to offer different products only in a bundle and not separately, while mixed bundling allows both. In this way, mixed bundling enables to discriminate between different consumer groups by providing a set of alternative offers. The potential benefit of this approach is shown in the following example.

Example 5.2. There are two products p_1 and p_2 and four customers c_1, \dots, c_4 . The willingness to pay vectors for the customers are given by $\{1, 9\}$, $\{4, 8\}$, $\{8, 4\}$, $\{9, 1\}$, respectively. In case the products are offered separately, it is optimal for the provider to set both prices at 8, giving him an eventual profit of $4 \cdot 8 = 32$. Employing pure bundling, the revenue is maximized by charging for the $\{p_1, p_2\}$ bundle 10 monetary units, thus, rendering 40 units for the provider through sales, as all customers will buy the bundle. However, by following a mixed bundling strategy, and setting the price for the bundle to 12 and for each product to 9 units, will render a profit of $2 \cdot 9 + 2 \cdot 12 = 42$ units – the first and last customer will buy the one product only, while the second and third customer will buy the bundle.

Amount-based pricing is usually applied when the product to be sold involves certain quantities. Examples would be the provision of a household with water, electricity and gas, or providing access to the internet, which may be based on time or the quantity of transmitted data. In this case, the provider of the respective good or service may offer the consumer to choose, for example, between a usage-based pricing (that is, fixed per quantity of used unit) or a fixed price independently of this amount, that is, a flat fee. Other amount-based pricing schemes would be to set a varying price depending on the quantity used (i.e., decreasing with a higher amount

²Note that these examples implicitly state the assumption that each customer's willingness to pay for a bundle of products is the sum of the willingness to pay for each single product contained in this bundle.

of used units) or combinations of usage-based pricings and flat fees (i.e., after a certain cap of used units is reached, the pricing scheme switches to a flat fee). For a more detailed discussion, see [Sundararajan \(2004\)](#). In general, it can be said, that flat fees are particularly useful for customers that consume large quantities of units, as therefore the average price per unit eventually approaches zero. On the other hand, it seems obvious that users with only a low consumption generally should favor usage-based pricing. However, it has been shown that even this kind of consumers often prefers flat fees, though from an economic point of view they are not optimal for them. In the recent literature, this phenomenon is also called *tariff bias* and is at least partially attributed to the so-called *taximeter effect*. For a deeper discussion of this topic see, for example, [Lambrecht and Skiera \(2006\)](#) and [Krämer \(2010\)](#).

In addition to the above pointed out pure pricing schemes for first and second degree price discrimination, there exist also various forms of pricing that cannot be assigned exclusively to one of these. One example of this is given by reverse pricing (see [Chernev \(2003\)](#)). The provider of a product has a secret price limit for which he is willing to sell his product. Each customer is allowed to state a bid, that is, how much he is willing to pay. If this bid is above the provider's price limit, the customer pays the amount according to his bid. Since successful bids are not announced to other customers than the original bidder, there is no price competition among the customers. Reverse pricing is thought of in-between static pricing (with an unknown fixed price) and personalized pricing. A market that actually implements this pricing scheme is <http://www.priceline.com/>.

5.1.2.3 Group Pricing

First degree price discrimination charges each customer individually (under perfect knowledge of the customers' preferences) and, thus, maximizes the (theoretical) profit. Since this is not feasible in practice, second degree price discrimination tries to avoid this complex problem by offering certain product alternatives (by versioning, bundling, or different billing schemes) and letting the customers choose by themselves what is optimal for them. Thus, discrimination takes place by customers' self-selection by means of their own choice between different products or tariffs. Third degree price discrimination, in contrast to second degree price discrimination, focuses on the customers again by directly using some observable characteristic of the customers. For instance, group pricing is a form of third degree price discrimination and approximates the idea of personalized pricing by subdividing customers not individually but rather into groups and, thus, rendering it applicable in real world scenarios. The challenge when applying group pricing is to subdivide the customers into groups that are robust and can be verified. Examples would be students, senior citizens, gender or citizenship biased, depending on the kind of product for sell.

Comparing Figs. 5.4 and 5.5 one notes the similarity between the realized profits achieved by both approaches, i.e., versioning and group pricing. The crucial difference is that versioning involves the customers' self-selection aspect,

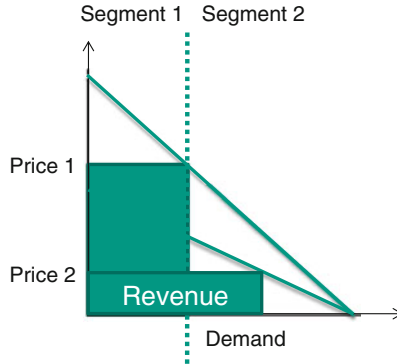


Fig. 5.5 Provider's revenue with group pricing

while in group pricing the customers' choice is limited by the group they belong to. Furthermore, while versioning works by varying product quality and additional features, group pricing usually is applied by (but is not limited to) monetary differentiation. It must be noted that both approaches can also be combined to even more complex pricing schemes, that is, offering specific versions only to a certain group of customers.

5.1.3 Dynamic Pricing

Dynamic pricing, according to Wikipedia, is applied in numerous fields. The general notion of dynamic pricing is that the product prices are determined according to usually complex dynamic pricing schemes that vary in dependency to several variables or additional conditions. These pricing schemes provide more flexibility than the above named static and flexible pricing approaches and, thus, enable the market participants to adapt better to actual market situations trying to maximize their profit or minimize their expenses. Albeit the more profound complexity of flexible over static pricing mechanisms, these approaches still do not enable any trader to systematically adapt their behavior to fast changing market situations. Dynamic pricing just offers providers as well as customers more options to act. However, this richer strategic space in dynamic pricing schemes is more challenging to control, that is, in the sense to, for example, find the (theoretically) optimal trading strategy. Usually, both providers and customers are involved actively in determining the outcome, or one side uses at least their expectation about the other side's behavior. It can be noted that time is often a crucial factor among the parameters used in the pricing formulas. This section particularly focuses on auctions as one kind of dynamic pricing. Other dynamic pricing schemes are presented in Chaps. 6 and 8.

Auctions are one of the most prominent example of dynamic pricing schemes. Depending on the specific auction type, both sides of the market are actively involved (for example, by stating their bids or reservation prices) and, additionally, are often in competition to other providers or consumers, respectively. Today the most distinct auction forms have been developed and established successfully. For many of these auctions optimal (bidding) behavior (given certain assumptions) can be shown analytically. The type of auction that is employed usually depends on the goods (and their characteristics) that are to be sold via the auction, often also involving historical and traditional aspects. Further readings about auctions, their characteristics and practical employment as well as theoretical aspects are given by Klemperer (1999), Krishna (2009), and Milgrom (2004). Note that auctions, in contrast to the mechanisms presented above, comprise pricing as well as allocation rules. The four most common auction types are the English, Dutch, first-price sealed-bid, and Vickrey auction.

In an English auction several customers compete for the same product (or set of products). Each bidder may state his bid which must be higher than the last bid that was stated openly by another competing consumer. Each bidder may adapt his bid repeatedly according to the other bidders' behavior. The bidders will leave the auction as soon as the price rises above their willingness to pay, which, in contrast to their stated bids, remains unknown to the other bidders. The last bidder remaining in the auction process is declared as the winner and pays his last bid as the price to acquire the product. English auctions are probably the most common auction form for selling paintings, antiquities or other assets whose value can hardly be estimated and is subject to a large dispersion among the bidders willingness to pay.

In a Dutch auction, the auctioneer publicly announces the current price for the good to be acquired. This price usually starts with a high reservation price and is decreased in priorly announced fixed steps until the first bidder accepts the price. This bidder wins the auction and pays the price that he accepted. Contrary to the English auction, the bidders in the Dutch auction can only state an equivalent of their bid by deciding how much time to wait until committing themselves to pay the actual price for the good. In this way, English auctions, where no fixed price interval for the next higher bid is set, may enable the bidders to more strategic behavior, for example, by raising the bid by an unusual high amount, thus, creating and exploiting psychological effects. Dutch auctions are mostly known for their application in Dutch flower selling markets but also have recently been established in online markets, for example, <http://www.1-2-3.tv/>.

In contrast to the sequential format of the English and Dutch auctions that allow increasing or decreasing bids, respectively, first-price sealed-bid auctions allow the bidders to submit just one bid. This bid is sealed and hence, only known to the bidder. It is stated independently from other participants' bids and thus, the procedure avoids any direct competition. It can be shown that in this auction form the participating consumers will not bid their true willingness to pay, but tend to understate it with their bid (see, e.g., Ausubel et al. (1996), Zeithammer (2007) and the references therein). This so called *bid shading* is also the result of

rational behavior in *Nash equilibrium*³ for first-price sealed-bid auctions. Prominent examples are, for example, (public) tenders.

The disadvantage of the first-price sealed bid auction is that no dominant strategies exist. While, for example, in the English auction it is clearly profitable for a customer to stay in the auction as long as the actual price is below the auction participant's willingness to pay, no such strategies exist neither for the Dutch nor for the first-price sealed-bid auction. A different approach is employed in the Vickrey auction that is carried out analogously to a first-price sealed-bid auction, with the exception of the price determination. Instead of paying his own bid for the good, the winning participant is obliged to pay the second highest bid. Therefore, the Vickrey auction is also called second-price sealed-bid auction.⁴ For this auction form it can be shown that it is a dominant strategy for each bidder to bid his own valuation, i.e., willingness to pay. This strategy is also known as *truth telling*.

A generalized format of the Vickrey auction is a multi-unit auction. In this case, bidders submit bids for single units as well as available bundles. The winner determination is carried out similarly to Vickrey auctions but requires the distribution of all available items. Hence, there can be single bidders that win with a highest bid for all of the items, or several bidders of which the (sealed) bids jointly form the highest bid. Price determination is carried out separately for each of the winning bidders. In order to calculate the price to be paid by bidder i , the maximum bid when removing the participant i 's bids is reduced by the originally winning bids without bidder i 's bids. The resulting amount reflects a theoretical second highest price.

The question that might now arise for a provider is via which auction form he should offer his products in order to achieve the (theoretically) highest revenue. Though no answer can be given in general, it can be stated that under certain mild assumptions about the bidders and their characteristics (see McAfee and McMillan (1987) for details) all the above four illustrated auctions yield the same outcome. This is also known as the *Revenue equivalence theorem*.

The above named auction types can be characterized according to the following attributes. Since in all depicted auctions only the consumers take an active role as bidders, the auctions are characterized as being *one-sided*. Double-sided auctions follow more complex bidding rules, involving the consumers as well as the providers stating their bids. Further characteristics are whether the bids are made public (i.e., open) or sealed, and whether these bids are stated in an ascending or descending order. This classification is illustrated in Fig. 5.6. Therefore, an English auction is an open ascending auction, while a Dutch auction is open but descending. Both the first-price sealed-bid as well as the Vickrey auction are one-sided, sealed auctions. Examples for double sided auctions are Call-markets (with sealed bids), as they occur at the start of each trading day at stock exchanges, and continuous double auctions (with open bids), which manage the ongoing trade in these exchanges.

³That is, no participating party can achieve a higher utility by unilaterally deviating from her bid determined in the equilibrium.

⁴ n th-price sealed-bid auctions can be defined analog.

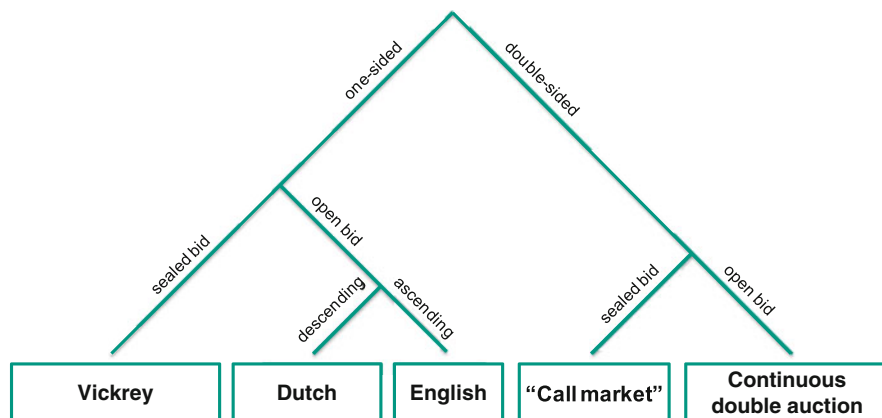


Fig. 5.6 Auction types classification

5.2 The Pricing of Web Services

The question that now arises is whether and how the pricing mechanisms presented in the previous section can be used for the pricing of Web services. The answer to this question must take into account the specific characteristics of Web services pointed out in Chap. 4 as well as the needs that may differ when customers acquire Web services instead of ordinary goods.

Static pricing, though in most cases not the optimal choice for the provider, can be applied as a pricing scheme for almost any goods, including Web services. For first degree price discrimination there are the same challenges for their application in Web service pricing as for other goods, that is, it remains a merely theoretical approach. As versioning and bundling has already successfully been employed with software sales, there is no constraint regarding its application in Web service markets. A similar argument holds for amount-based pricing. Therefore, for second degree pricing schemes, there is no restriction regarding their usage in pricing Web services.

Group pricing is also a promising approach to be employed within the sales of Web services. In traditional group pricing scenarios, group segmentation and the verification of the affiliation of customers may be challenging (or, at least, not automated) in particular cases. The advantage of applying third degree price discrimination in Web service markets is that Web service providers may use the already established infrastructure (including authentication and authorization) that exist for virtual organizations (see, e.g., [Foster et al. \(2001\)](#)).

There are no apparent arguments against the application of any of the flexible pricing schemes to Web service pricing. This, however, cannot be said automatically for dynamic pricing, for which specific aspects of Web services and their related trading need to be taken into account. As Web services form often part of some

automated processes (in, e.g., Service Value Networks, illustrated in Chap. 3) the sometimes time consuming price and allocation mechanisms of the above depicted auctions (e.g., the English and Dutch auctions) might hinder the application of these schemes in Web service markets. Even if one considers usage of automated bidding processes and agents (see, e.g., [Borissov \(2009\)](#)), this only diminishes the dimension of this problem. Also, introducing the option to buy auctioned Web services instantaneously is not satisfying. This immediate purchase option, while bypassing the regular auction procedure, will cost the consumer a posted price that will usually be above the expected price the Web service would yield in the regular auction process, thus, denoting an additional charge. For Web services whose usage can be planned in advance, the implementation of auctions as Web service market mechanisms states no contradiction. The above named restrictions do not hold for all dynamic pricing schemes, of course, as will be illustrated in the following Chaps. 6 and 8.

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Business Aspects of Web Services

Weinhardt, C.; Blau, B.; Conte, T.; Filipova-Neumann, L.;

Meinl, Th.; Michalk, W.

2011, XII, 200 p., Hardcover

ISBN: 978-3-642-22446-1