
Pricing web services

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Abstract: This paper focuses on the challenges associated with composing and pricing web services. We present the results of an online experiment, where subjects were confronted with a variety of choices and decisions relating to web service markets and service composition. Our analysis shows that people expect the price of a composite web service to be lower than the sum of the prices of the elementary services, that is, users are not willing to pay for aggregation by a third party. To obtain a viable business model for composite web services, non-standard pricing mechanisms, such as auctions and negotiations, possibly supported by electronic agents, have to be taken into consideration. Usage-based pricing schemes, combined with an option to switch to a flat subscription, seem most appropriate to penetrate the developing market for web services.

Keywords: web services; pricing; composition; web-based; service-oriented architectures; SOAs.

Reference to this paper should be made as follows: Günther, O., Tamm, G. and Leymann, F. (2007) 'Pricing web services', *Int. J. Business Process Integration and Management*, Vol. 2, No. 2, pp.132–140.

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1 Introduction

Over the past decade, web services have become an economic reality. Nevertheless, the formation of prices for web services is still an open issue. In order to be profitable, a web service provider requires detailed knowledge about customers' willingness to pay, about the costs

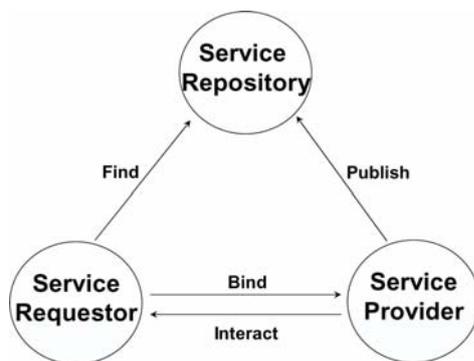
associated with providing the web service, and about price elasticities on the customer and the supplier side. This knowledge is rarely available, and more empirical research is required to obtain insights into behavioural patterns on both the customer and the service provider sides.

Walras (1883) started the field of price theory with his work on auctioneer markets, where prices are negotiated

directly and simultaneously. He described a market equilibrium with one unique competitive price for a traded product. Choi et al. (1997) found that modern information technologies can be used to create specific customer profiles and allow almost perfect price discrimination. Nevertheless, price formation on electronic B2B markets still takes place mostly with static price setting models. Most researchers expect a rise of dynamic models, such as auctions (Easley and Tenorio, 2004) and negotiations (Kafka et al., 2000), and an increasing automation of selling and purchasing processes. In this paper, we discuss how to apply these insights to web service markets. Based on Techopitayakul and Johnson (2001) we discuss ways to spread the risk associated with using an elementary web service in a composite setting. We also discuss the role of options in this context.

Service-Oriented Architectures (SOAs) imply three basic roles or fundamental operations (Figure 1). On the demand side, a service requestor (the customer) requires a web service. To find an adequate service, the service requestor is likely to use a specialised service repository, which offers semantic information about web services along with technical descriptions and addresses to locate them. In order to be found, a service provider needs to publish its web service at a variety of service repositories. After collecting all the necessary information and adjusting to the technical requirements, the service requestor is then able to use the web service. Closely tied to the concept of SOA is the idea of loose coupling, which implies that the constituent parts of a composite web service are easy to replace. Loose coupling requires interfaces that are not bound to concrete implementations.

Figure 1 Roles in a service-oriented architecture



For the purpose of composing (a.k.a. aggregating) web services, it is necessary to introduce the role of a web service aggregator. The web service aggregator acts as a mediator between customers, who have expressed a demand for a composite service, and suppliers, who deliver simpler web services. On the supply side, the simpler services may be elementary or composite in turn. The aggregator can then adopt all of the fundamental operations (find, bind and publish) described in the SOA role model. The service aggregator operates as a service provider to its customers and as a service requestor to its suppliers. In acting as a mediator between supply and demand, it may also adopt functions assigned to a service repository, such as rights management or even performance monitoring.

There are a number of standardisation initiatives that deal with various aspects of composing web services. Because of its widespread support among software vendors, the Business Process Execution Language for Web Services (BPEL4WS, 2007) seems to have emerged as the dominant standard in the area of workflows. Other proposals in discussion include the Web Service Conversation Language developed by Hewlett-Packard and a vendor-neutral choreography specification submitted by the Web Services Choreography Working Group at the W3C.

This paper focuses on the pricing of web services. There are a number of challenges associated with composing a service that provides added value to all parties involved. To be commercially feasible, web service aggregators need to be able to make a profit. This implies the investigation of appropriate cost and pricing models for service composition from the perspective of a web service aggregator and its partners. Section 2 presents an example scenario to study these issues. Section 3 presents the results of various empirical studies and Section 4 concludes with a summary and a number of strategic recommendations.

2 An example scenario

To obtain insights into the perceptions and preferences of the players in the web service market, we conducted a number of online experiments. In particular, we observed the decision-making processes of a web service aggregator when faced with different possible pricing models. We addressed the following central questions:

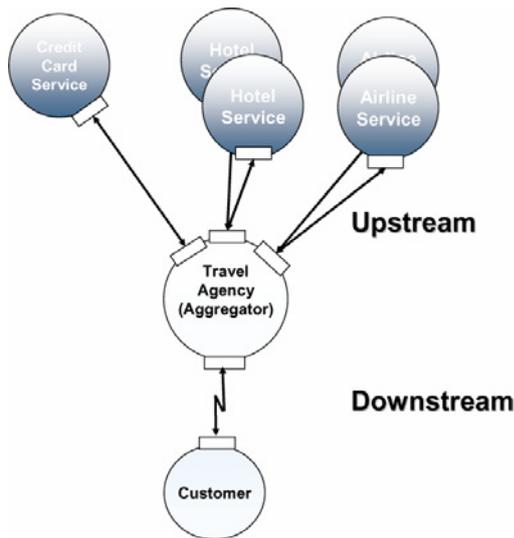
- Which pricing mechanisms are most appropriate for web services?
- What are the preference structures of service aggregators, providers and requestors?
- Which correlations exist between the willingness to pay for a composite web service, its underlying elementary services and different properties of this service?

We based our experiments on a simple travel agency scenario. The test subjects were 242 business and economics students at Humboldt-Universität (for the use of students as test subjects in economic experiments, see Dyer et al., 1989). The subjects were first introduced to the concept of web services and application service providers. We conducted some short surveys to capture the awareness and attitude of the respondents with respect to the relevant technologies, as well as their risk preferences.

We then asked them to put themselves into the position of a travel agent who wants to compose a web service for travel planning from a number of elementary services (Figure 2). In the upstream market, the travel agency has contracts with external suppliers (e.g. a flight reservation service, car reservation service, hotel reservation service, payment service) who compete for price and quality of their elementary and composite web services. Note that these suppliers may be service aggregators in turn. Therefore, it is important how the agency assesses the

value of these services and how much it wants to pay for them. In the downstream market, the travel agency offers its products and generates revenues. It also tries to gauge how customers assess the value of the provided services. This translates into customers' willingness to pay and therefore has a crucial impact on the agency's price-setting policies. Note that the term willingness to pay is used to represent the amount of money customers are prepared to spend on a given web service, independent of its market price.

Figure 2 Aggregation of web services



As previous experiments have shown, the low marginal costs associated with digital services have a negative impact on customers' willingness to pay. Fixed costs usually have a more limited impact on customers' perceptions. Thus, although our agency is confronted with high fixed expenditures for hardware, maintenance and general administration, the perceived value of its products is relatively small.

Without additional measures to increase customers' willingness to pay beyond this a priori value, the agency would not be able to break even. It is therefore essential for the travel agency to stimulate the willingness of its customers to pay much beyond the marginal costs by providing them with additional value. Typical measures include product differentiation and price discrimination. In the case of product differentiation, each provider tries to offer a service with unique functionalities that distinguish it clearly from competing offerings. Typical product differentiation strategies include personalisation, bundling and versioning. Price discrimination refers to the phenomenon of a product being sold at different prices, where the variances in price are not based on higher or lower production costs but on different utilities provided to different classes of customers. Customers' individual utilities are reflected in their willingness to pay.

3 Experimental results

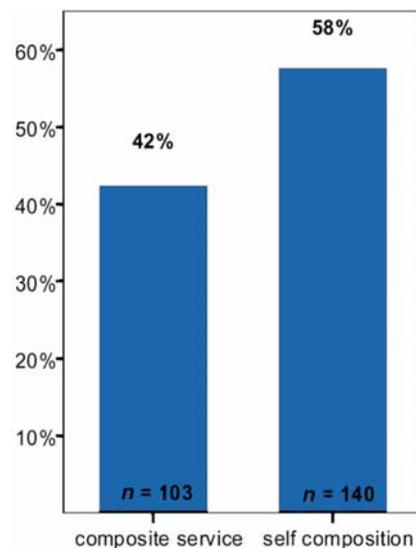
In our online experiments, we investigated the preferences regarding the composition of web services and the

willingness to pay for a composite web service. Furthermore, we examined the preference for different pricing models, such as subscriptions, usage based pricing or auctions in conjunction with options. Starting from considerations on product differentiation introduced above we observed preferences and the willingness to pay for different properties of a web service. We discuss these results in turn.

3.1 Composite versus elementary services

The composition of a web service is associated with various risks and costs, such as the expenses for locating and discovering elementary services, obtaining appropriate knowledge or simply higher transaction costs due to the increased number of contractual partners. We therefore originally assumed that most decision-makers in the role of the travel agency would be willing to pay a risk premium for a precomposed web service, rather than composing a service themselves. To test this hypothesis, we put the test subjects into the situation of the online travel agency. In addition to using elementary services individually, it was assumed that the agency can also acquire these services as a composite service. The respondents were asked if this option (all other things being equal) was preferred to the choice of building the composite service on their own. The results in Figure 3 show that a majority of subjects tends towards composing the service themselves, presumably because that is considered a core competency of the travel agency.

Figure 3 Make or buy decision for a composite web service



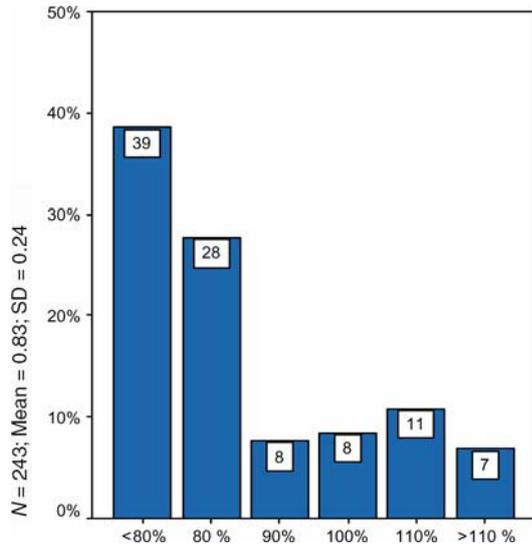
Our next test was aimed at eliciting the willingness to pay for a composite web service. The respondents were provided with the following subscription prices for the elementary services (€ per year of unlimited usage):

- *Flight Reservation Service*: 3000 €
- *Car Reservation Service*: 3000 €
- *Hotel Reservation Service*: 2000 €.

We then asked the subjects how much they were willing to pay for a composite web service comprising all the

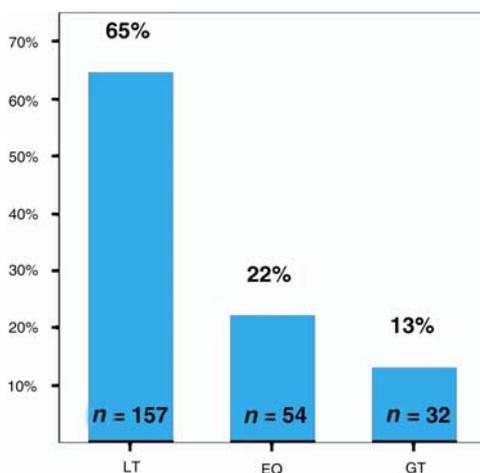
functionalities of these elementary services. As shown in Figure 4, only 26% of all subjects were willing to pay as much (or more) for the composite service as for the individual services – even though self-composition implies quite a bit of extra work. About 74% of the subjects expected a discount, with an average willingness to pay an amount of 6602 € (standard deviation of 1913 €), compared to 8000 € total value for the elementary services.

Figure 4 Willingness to pay for a composite web service



We obtained similar results when we changed the context to an online auction, where it was possible to bid for either the composite service or for the elementary services. The respondents were asked up to what price they were willing to bid for the composite service, with choices being *Less Than (LT)*, *Equal To (EQ)* or *More Than (GT)* the expected sum of prices for the elementary services. Figure 5 shows that the great majority of subjects still expect to pay less for the composite service. We explain this behaviour by drawing an analogy from daily life. When people book a complex trip involving, for example, a flight, a rental car reservation and several hotel reservations, they usually expect a discount when booking a package. This ‘package mentality’ seems to carry over to service composition.

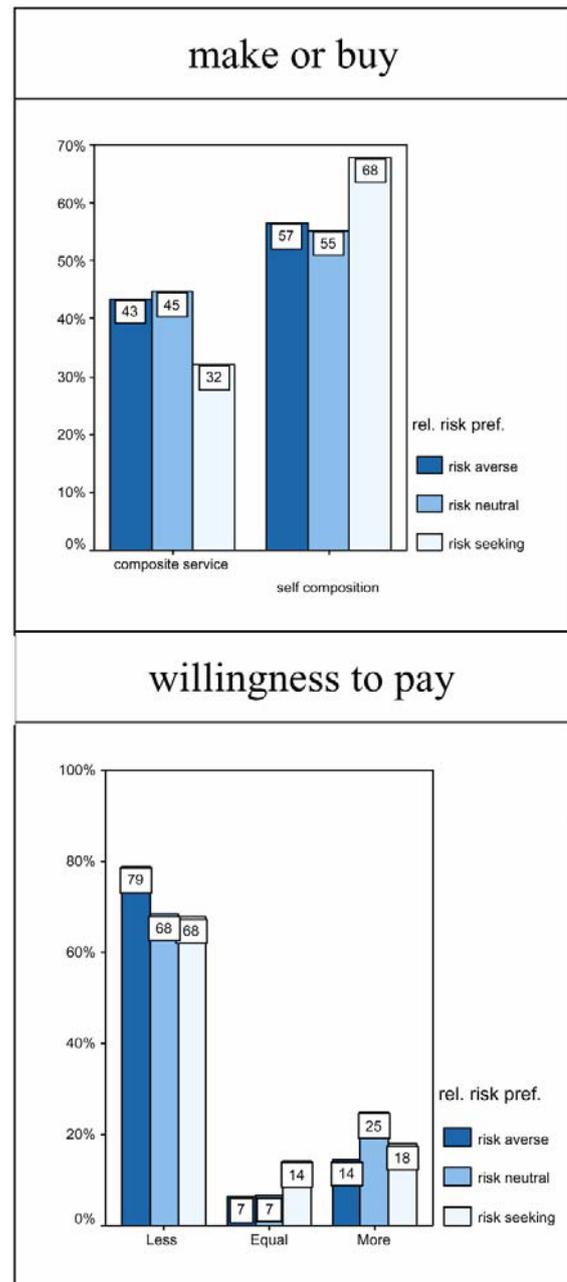
Figure 5 Auction of composite versus elementary services



We then used a certainty equivalent method called *midpoint chaining method* (Farquhar, 1984) to divide our

subject pool into three groups: relatively risk averse ($n = 139$), risk neutral ($n = 76$) and risk seeking ($n = 27$). As depicted in Figure 6, risk seekers seem to have a notably stronger preference to bundle a composite service on their own. Moreover, we could not substantiate our original hypothesis that in the case of a risk-averse attitude people are willing to pay a risk premium. Risk-averse subjects expose a stronger ‘package mentality’ than the average participant.

Figure 6 Risk preferences and web service composition



Our results suggest that the value added by composing a web service is not rewarded. Contrary to our hypothesis, the majority of the participants prefer to compose a web service themselves rather than buying a composite service. The great majority of participants are expecting a discount for buying the package. This should not be confounded with the statement sometimes found in the literature that people are willing to pay *more* for the collection of

elementary services than for the composite service. They probably would buy neither the elementary services nor the composite service if the composite service was more expensive. But in order to be successful in the market place, service aggregators need to negotiate deals with their suppliers that allow them to offer package prices well below the total market price of their components.

3.2 Subscription versus usage-based pricing

At first sight, usage-based pricing models seem to be particularly well suited for web services. However, for customers who are in doubt about future usage levels, the costs associated with this pricing model are very difficult to anticipate. Techopiyakul and Johnson (2001) therefore suggest a usage-based pricing structure combined with an option to switch to a flat subscription fee in order to provide customers with an upper limit on costs. This part of our experiment is aimed at testing to what extent such options can be utilised to reduce the aforementioned uncertainties. We will test two hypotheses:

- 1 in case of an anticipated low usage level a usage-based fee will be preferred, otherwise a flat subscription
- 2 customers will opt for usage-based pricing combined with an option to switch to a flat subscription fee if there are substantial uncertainties about future usage levels.

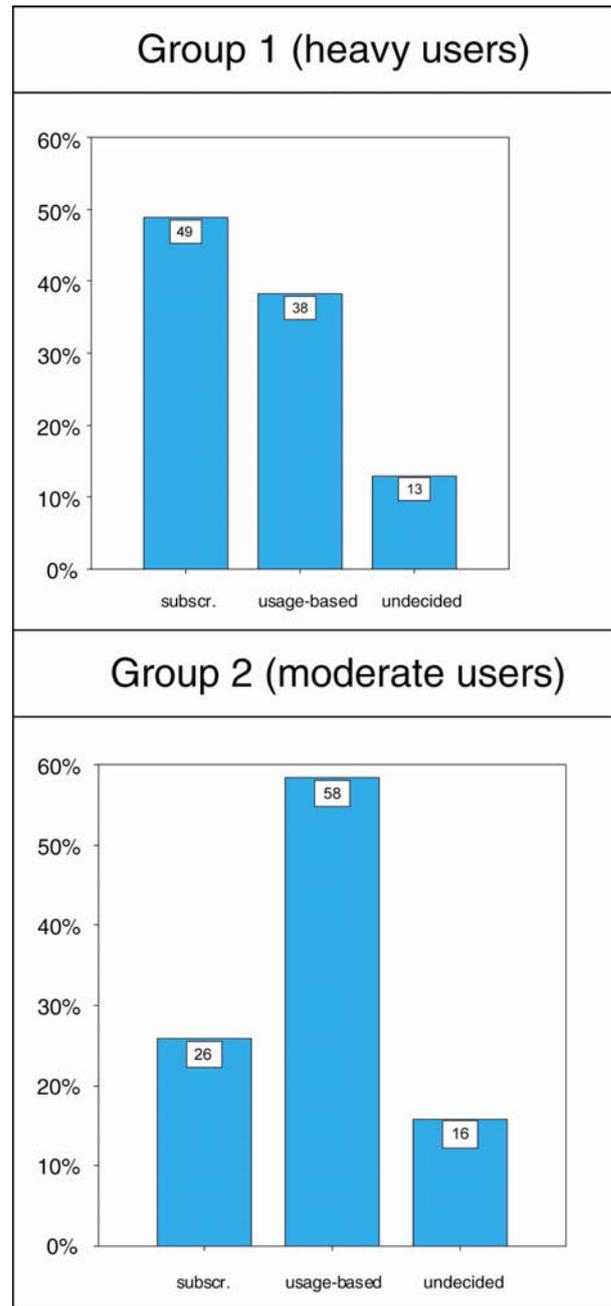
To test these hypotheses, we randomly divided the population of respondents into two equal groups. In order to model uncertainty in terms of usage, each group was provided with three discrete possible usage levels, associated with specific prices and probabilities. In terms of expected usage, the choices presented to group 1 ('heavy users') represent a much higher usage level than the choices presented to group 2 (the 'moderate users'). Furthermore, we specified the price of a subscription to be equal to the expected consumption of the moderate users given usage-based pricing. Table 1 summarises the relevant parameters.

Table 1 Subscription versus usage-based pricing: setup

Price of the subscription	6000€
Expected usage (given usage-based pricing)	
Group 1 (heavy users)	7250€
Group 2 (moderate users)	6000€

After introducing the scenario, the participants were asked whether they would prefer a subscription fee, usage-based pricing or if they were undecided on the issue. Note that we did not supply the expected values of usage-based pricing to the subjects. Figure 7 shows that the heavy users (group 1) naturally tend towards a subscription while the moderate users (group 2) prefer a usage-based pricing model.

Figure 7 Subscription versus usage-based pricing: results

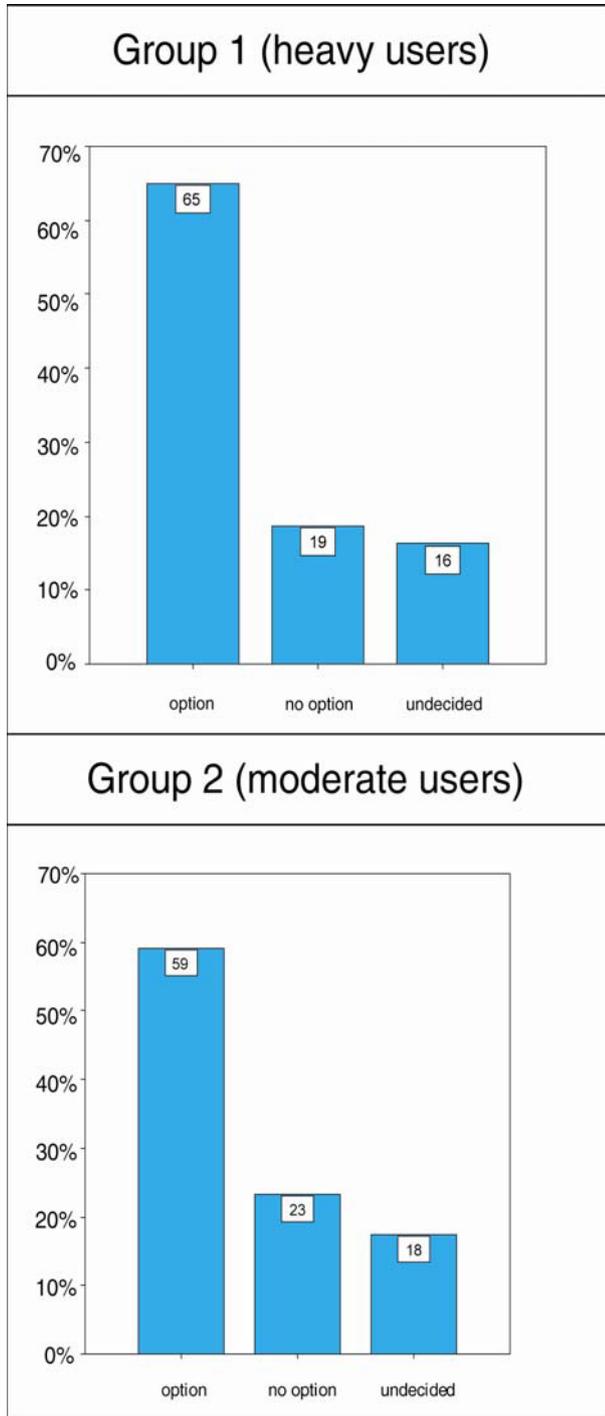


Afterwards we offered the subjects a usage-based pricing model that was linked to an option. The option enables its holder to switch to the subscription in case the fees resulting from the usage-based pricing exceed the price of the flat subscription fee. The respondents were asked whether there are willing to pay for that option an amount of 10% of the original subscription fee. As shown in Figure 8, a large majority of subjects voted in favour of purchasing the option. As expected, heavy users (group 1) are slightly more interested in the option than moderate users (group 2).

We then tried to correlate this behaviour with the risk preferences of the subjects. As can be seen in the upper graph in Figure 9, group 1 (heavy users) shows inconsistent behaviour pertaining to the relationship between risk preference and the choice of a pricing model. Contrary to our expectation, the responses of risk-averse participants are nearly equally distributed between

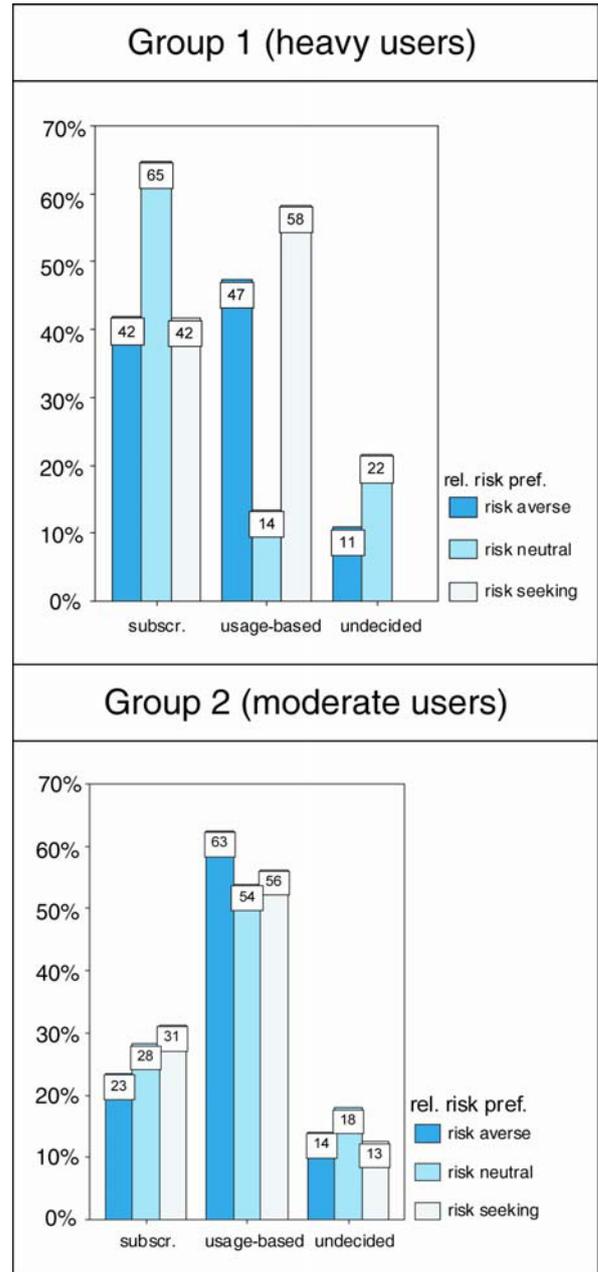
subscription and usage-based pricing. The results for group 2 (moderate users) reflect the findings made in the experiment, with no significant differences between the risk preference categories.

Figure 8 Usage-based pricing with option to switch



The findings of our research suggest a usage-based pricing structure combined with an option to switch to a flat subscription fee. For customers who are in doubt about future usage levels, costs associated with a usage-based pricing model are difficult to anticipate. Such a pricing model will provide them with an upper limit on their costs. This pricing model is suggested for penetrating a low-usage market. Our experiment implies that there exists a sufficient willingness to pay for such an option.

Figure 9 Risk preferences and the choice of subscription versus usage-based pricing



3.3 Auctions versus fixed prices

Due to the generally uncertain outcome of auctions and the resulting risk, we presume that a (risk-averse) web service user usually prefers a fixed price to an auction. We shall now examine whether this assumption holds if the participation in an auction for a web service is combined with a call option on that service, that is, if the auction implies the possibility to switch from usage-based pricing to a subscription model.

In order to test this hypothesis, we randomly divided the subject pool into two groups of equal size. We confronted each group with three different possible outcomes in the auction, complete with probabilities. Furthermore, we supplied a fixed price for a yearly subscription for the underlying service. For the first group, the expected outcome of price of the auction was significantly below the subscription price. For the second group, the

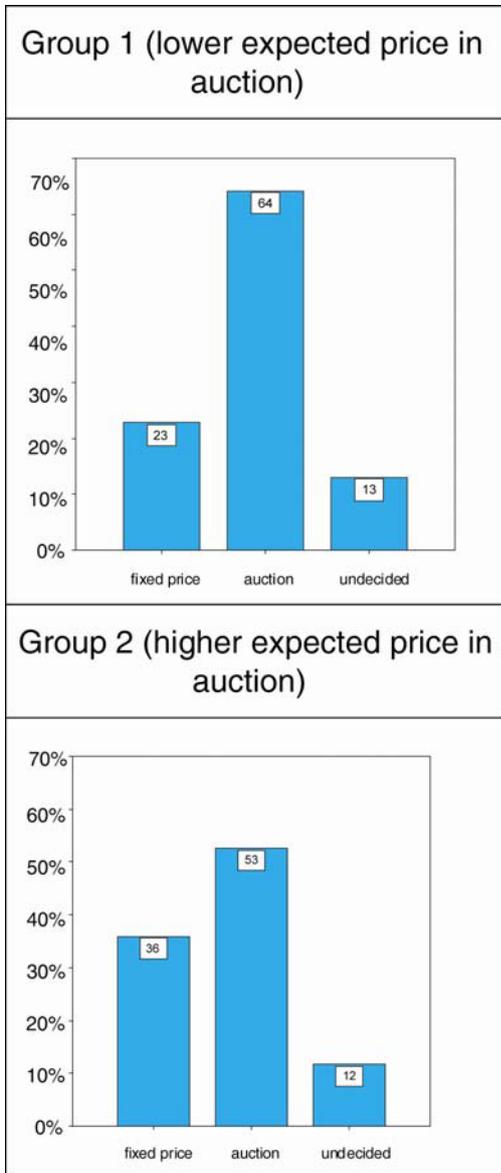
expected outcome of the auction was still below the subscription price but the difference was considerably less (Table 2).

Table 2 Fixed price versus auction

Subscription price	3500€
Expected price in the auction	
Group 1	2900€
Group 2	3300€

The subjects were then asked whether they would prefer the fixed price, the auction or whether they were indifferent on the issue. Figure 10 shows a clear preference for the auction in both groups. The lower expected price sufficed to convince the users to accept the higher risk associated with an auction.

Figure 10 Auction versus fixed price



The respondents who did not vote in favour of the auction or were undecided were then asked whether they would change their minds if the auction were linked to an option, which gave its holder the right (but not the obligation) to

buy the underlying service for a strike price of 3600€. Figure 11 shows that this increases the attractiveness of the auction considerably. Almost half of the subjects who were previously opposed to the auction did now vote in favour. As shown in Figure 12, there are no significant differences in the choice of a particular pricing model among the different risk preference groups.

Figure 11 Auction combined with call option

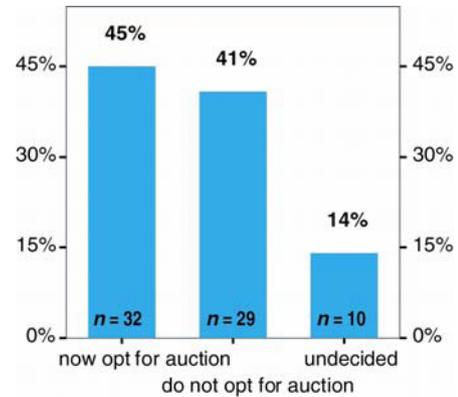
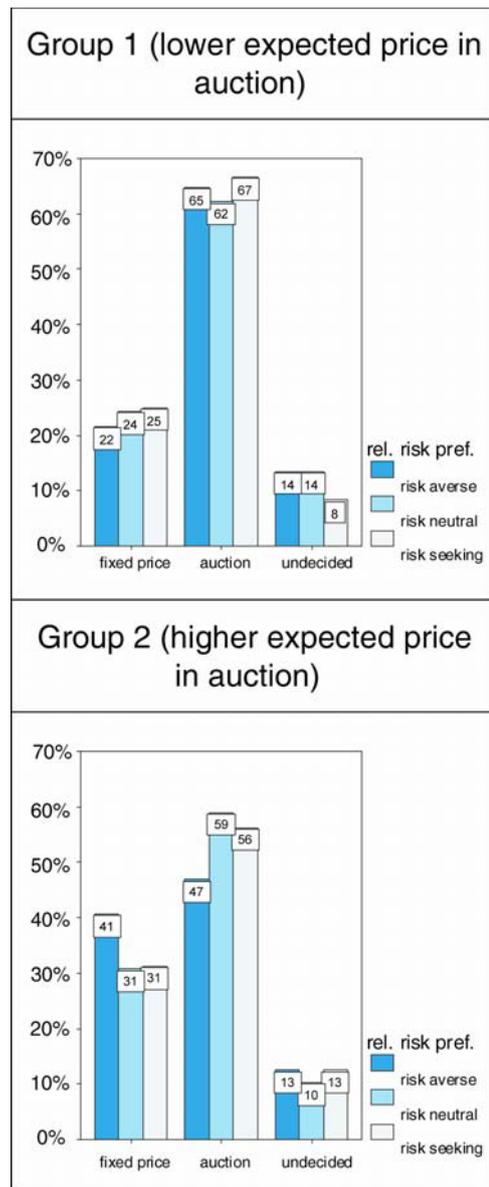


Figure 12 Risk preferences versus interest in auctions



In conclusion, auctions seem to be an interesting pricing alternative for web services, especially when customers are still unclear how much they will use the services being offered. In order to reduce the perceived risk linked to auctions, providers should consider offering an option model, where customers can switch to a fixed strike price.

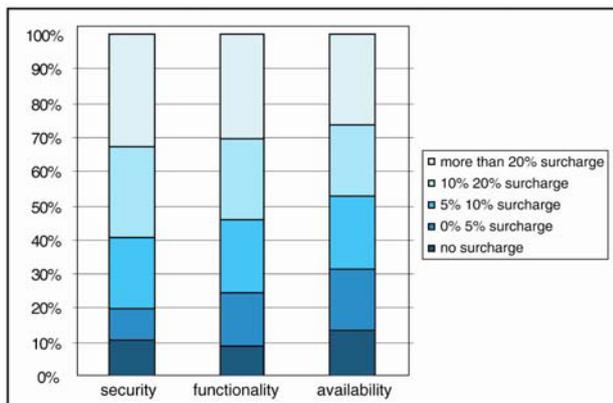
3.4 Willingness to pay for special features

One of the goals of our experiment was to determine whether web services fit into the differentiated product model. In a differentiated product market the same 'kind' of goods and services are produced by a number of firms, but with many different varieties (Shapiro and Varian, 1998). Differentiation from the competition is therefore achieved by adding special value to its products.

To investigate this situation, we introduced a web service to which we subsequently added value by either offering to operate the service over a secure delivery channel, or increasing its availability, or extending its functionality. The respondents were then asked how much they are willing to pay for each of the improvements for the service in addition to the yearly subscription of 3000€.

As shown in Figure 13, a large majority was willing to pay a significant surcharge for a better quality of the web service in question. Customers seem to be willing to pay for special and uncommon properties of web services. This outcome substantiates the hypothesis that web services are compliant with the concept of a differentiated product model.

Figure 13 Willingness to pay for different properties of a web service



4 Conclusions and outlook

In this paper, we studied pricing mechanisms for composite web services and their integration into new or existing web service standards. Our analysis shows that there is a considerable flexibility regarding possible pricing mechanisms. While up to now, the most common pricing models are based on fixed prices and subscriptions, more dynamic approaches such as auctions and negotiations are gaining considerable momentum. This is partly due to improved technical support and partial automation for such approaches by electronic agents and similar technologies.

This paper's main original findings were based on an online experiment, where 242 subjects were confronted with a variety of choices and decisions related to web service markets and service composition. Our results illustrate the economic concepts that are relevant for these markets and highlight the most important problem areas. Our main conclusions are as follows.

Price discrimination and product differentiation: our experiments show that most potential customers expect to pay less for a composite service than the total of the components' prices. The customers' assumption seems to be that web service aggregators have a better negotiation position in the upstream market, which leads to discounts and similar cost advantages when purchasing elementary services. Customers expect these cost advantages to be passed on to them and are not willing to honour the costs and risks associated with the business of being a service aggregator. One strategy to solve this problem is based on price discrimination and product differentiation. In the short term, the web service aggregator may use a low price strategy to become the price leader for a particular composite service. Ideally, the service differentiates itself clearly from competing products, for example, by special functionalities or certain service guarantees. This combination of price discrimination and product differentiation may lead to a rapidly increasing number of customers and a high market share. In the long term, a monopoly situation is created, giving an opportunity to raise prices and thus increasing profits. Note that this strategy assumes a good financial background of the web service aggregator, something that is usually only true for larger vendors.

Modular offerings: in our experiments, participants often had a preference to compose a desired web service themselves rather than buying a precomposed service. Important parameters in this context include the internal and external transaction costs, the technical know-how of aggregating web services and the quality level required. Especially in B2B markets, it is important to give the customer some flexibility in the composition of web services. To maximise revenues, a web service aggregator should give its customers some choice between buying a composite service and composing the desired service themselves from a menu of basic services. This increases customer loyalty even in a changing market environment.

Options and other flexible pricing schemes: customers are more willing to use a service if they are given some flexibility concerning the pricing scheme. In our experiments we observed in particular that customers want an option to switch from a usage-based pricing model to a subscription (flat rate) and back. The experiments also showed that participants prefer auctions to fixed prices, even if the expected prices are identical. This observation should motivate service providers to offer different pricing models with an option to switch. To implement such flexible pricing schemes most efficiently, web service aggregators should consider software agents and similar technologies to automate functions like negotiations or bidding. Even more important, aggregators need to maintain probabilistic models of both the upstream and the

downstream market to forecast future earnings and expenses. These probabilistic models need to address which pricing models will be chosen by how many customers and which revenues can be expected, based on these choices. They provide crucial input for service aggregators to set prices and policies in such a way that they operate profitably.

Service Level Agreements (SLAs): when proposing SLAs to customers, web service aggregators need to take the service situation on the upstream market into account. A composite service is as weak as its weakest link. If a composite service is made up of, say, 10 elementary services, each of which has a probability of failure of 0.1%, the probability of failure of the composite service is as high as 1%. This ‘curse of probability’ needs to have two consequences. On the one hand, SLAs for a composite service need to be based on the probability that any one component fails at any time. Penalties on both the upstream and the downstream market need to reflect those different risks. On the other hand, composite services should be configured in a way that the failure of a single component does not necessarily block the composite service altogether. The composite service should be robust in the sense that those functionalities that do not require the failed component service remain functional. In an SOA this is typically achieved via dynamic service selection. SLAs need to reflect this possibility that a composite service is only ‘partially’ available, due to the failure of one or more of its components.

Standardisation: the availability of different pricing models needs to be reflected in related standards as well. Existing intermediaries like UDDI need to be extended to support market transactions, including more complex and more flexible ones, such as negotiations or auctions. Also, corresponding policies (WS-Policy, 2007) could be specified and attached to services.

Acknowledgement

The authors would like to thank Markus Banach and Kai-Uwe Ruhse for research assistantship.

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