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# An Economic Model to Study Dependencies between Independent Software Vendors and Application Service Providers

NADÈGE MARCHAND * marchand@gate.cnrs.fr
*Laboratoire G.A.T.E, CNRS-UMR, B.P. 167, 69131 Ecully Cedex, France*

H.-ARNO JACOBSEN ** jacobsen@eecg.toronto.edu
*Department of Electrical and Computer Engineering and Department of Computer Science, University of Toronto, Canada*

*Abstract*

Application outsourcing refers to the emerging trend of deploying applications over the Internet, rather than installing them in the local environment. This shifts the burden of installing, maintaining, and upgrading an application from the application user to the remote Application Service Provider (ASP). The ASP takes over all server administration and application management tasks. This deployment model allows applications to be distributed on a highly differentiable basis. This is in contrast to the traditional license-based software distribution model, where a customer receives "all-or-nothing" of the product and must manage the application on its own. To better understand dependencies between these two distribution models we propose an economic model to study the effects of actions of an independent software vendor on the profitability of an application service provider.

**Keywords:** Application Service Provider, pricing model, equilibrium analysis, software licensing, software leasing, application outsourcing

## 1. Introduction

The increase in network bandwidth, the growth of computing server performance, and the growing acceptance of the Internet as communication medium has given rise to a new software distribution model—*application outsourcing and software leasing*. Application outsourcing refers to the emerging trend of deploying applications over the Internet, rather than installing them in the local environment. This shifts the burden of installing, maintaining, and upgrading an application from the application user to the remote computing center, henceforth referred to as *Application Service Provider* (ASP).

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System administration and application management is entirely performed by the ASP. With this model it becomes possible to charge a user on a *pay-per-use* basis, differentiable on a very fine-grained scale, such as amount of system resources consumed (e.g., system interaction, data storage, computations), application functionality required, transactions executed, or simply based on a periodic or flat fee pricing model, as well as any combination of the former. Furthermore, an ASP may differentiate its services by offering a variety of *service level agreements*. This may account, for instance, for minimum network latency guarantees, minimum computing resource availability and throughput guarantees, and different service schedules (e.g., hot-line service and data back-up schedules). Thus, rather than selling a software license—giving a user "all or nothing" of a product—the software may be *leased* to the user.

Hosting of database backed web-sites[1], computational server farms[2], infrastructure for computing servers (i.e., secured and reinforced buildings, high-capacity network links etc.)[3], online (financial) computing services[4], remote email and document management[5], accounting and billing systems in the telecommunication world, and Web information systems of all sorts are initial example application scenarios of this model.

However, in the long term the ASP-model aims at including the online access to enterprise resource planning applications (ERP)[6] (Wilson, 1999; Gilbert and Sweat, 1999), business administration applications, human resource management, health-care[7] and insurance management systems, and system security management. These more complex application scenarios offered as ASP solution will mostly target the small and medium size customer (firms), that require less set up and business model adaptation[8], and may not be able to afford fully fledged ERP systems and support for a local installation and lengthy customizations (Gilbert and Sweat, 1999; Gill, 1999; Wilson, 1999).

While many of the technical aspects of such a software deployment model have already been thoroughly investigated (Jacobsen, Günther, and Riessen, 2000; Jacobsen and Günther, 1999), business strategic and information economic questions remain to be explored. The ASP-model is just emerging as business opportunity. From an economic point of view this model raises new profit opportunities that may effect the "traditional" independent software vendor (ISV) market, the emerging application service provider market, and relationships among the former. Two alternative economic scenarios may be envisioned, either competitively opposing application leasing and licensing, or combining both in complementary fashion.

On the one hand, independent software vendors and application service providers may be competitors. In this sense, the applications provided in either model constitute *substitute products*, i.e., one application replaces the other. To date, perfect substitutes to licensed applications (i.e., providing a perfect copy of the licensed application online as leased application service) are not yet available. This is mainly due to technological limitations. However, in the near future we expect that it will become possible to develop perfect substitute applications (i.e., same look and feel) for the license-based software distribution model.[9] First solutions [10] that permit to deploy any application in a leased fashion in local area networks are emerging. Other examples include full accessibility to office packages over the network, that may substitute locally installed office packages (Sun Microsystems, 2000; Gardner, 1999).

On the other hand, bundling of licensed software packages with ASP-services (or vice versa) constitutes another economic alternative. In this sense, the two deployment models constitute *complement products*, i.e., one form adds additional value in combination with the other (cf. Buckmann (2000) for commercial announcements following this line of thought).

From an information economic point of view, the ASP-model changes several important factors that determine market behavior for license-based software distribution and distribution of information goods, in general. These factors include reduced switching cost, decreased hardware and application vendor lock-in, changes to after-market revenue sources, significant marginal cost, and lower transaction cost. As a consequence, the ASP-model sharply erodes the local monopoly benefiting software vendors on the traditional software license market. This difference influences the strategies of ISVs and ASPs in their respective markets and interactions.

Questions such as the following arise: *How will the emergence of application service providers effect licensed-based software distribution? How will decisions of independent software vendors to act on the ASP market, or to sell or license their products to ASPs change their revenue stream and affect their sales on the software license market?* Opinions on these issues in the trade press are varied (Foley, 1999; Burney and Hecht, 1999; Luening, 1998; Girard, 2000; Louderback, 2000; Foley, 2000). We cite a few examples:

> *"A battle is brewing that could drastically reshape the normally staid world of business software."* (Girard, 2000).
>
> *"Software makers say the coming wave of business application hosting services will create a new market for their products."* (Luening, 1998).
>
> *"Traditional packaged software companies [...] should expect to take an initial hit in revenues as they make the switch to the new hosting model and begin offering their software through application service providers, said analysts."* (Luening, 1998).
>
> *"Vendor claims it could derive 50 percent of its license revenue from hosting in two years."* (Foley, 2000).
>
> *"Oracle to sell to ASPs? Over Ellison's dead body"* (Foley, 1999).

In this paper, in a first attempt to formally answer some of the questions raised above, we develop a formal framework that relates independent software vendor and application service provider activities economically. We propose an economic model to describe and to analyze the implications of traditional software license distribution on ASP firm activities. We study the effects of activities by independent software vendors (e.g., raising of sales, price shocks, release of new product versions) on the profitability of application service providers. Our model consists of a multi-market oligopoly model in order to investigate the dependencies and effects between a monopoly market, where the acting player is an independent software vendor, and an oligopoly market, where the acting players are application service provider firms.

The rest of the paper is organized as follows. Section 2 gives a more detailed description of the ASP-model and its relation to license-based software distribution. Section 3 develops and applies the economic model developed in this paper to study dependencies between license-based software distribution and software leasing. Section 5 summarizes related work and Section 6 discusses our main results.

## 2. Information economy and application outsourcing

The Information Economy addresses economic principles governing the exchange of *information goods*. Information goods are products consisting of information: “Essentially anything that can be digitized [...]” (Shapiro and Varian, 1998). Economically, information goods are characterized by high fixed cost and low marginal cost. It is very expensive to produce the first copy of an information good, but its reproduction cost are negligibly small, possibly zero. Examples of information goods are software applications, databases, information systems, movies, music, and books. In the following we focus our discussion on information goods accessible and distributed via communication networks to be better able to compare their characteristics with the characteristics of *application services*. The same arguments apply to information goods distributed through other channels.

In this sense, outputs produced by *information systems*, such as search engines, stock tracking systems, messaging systems, and travel planning systems constitute information goods. They maintain the same economic characteristics as “static” information goods. The cost for building the database and developing the information system implementation are very high (cost of first query executed); the cost for each subsequent query is negligibly small.

Application outsourcing, on the contrary, involves the remote management of computing resources (e.g., security management at client site), application service providing—an ASP manages an application package for its clients (e.g., enterprise resource planning and supply chain management solutions)—or dynamic allocation of computing resources (e.g., management of peak loads for Web portals and Web caches).

Thus, the *application services* provided are highly specialized applications and particularly customized to the needs and business model of a customer. They involve a considerable initial set up cost per client, demand continuing support cost per client, require the allocation of significant amounts of computing resources per unit of service offered, provide complementary services (e.g., data backup, recovery, security), and must guarantee an acceptable level of quality of service. The latter refers to availability and reliability commitments for the application services offered. None of these characteristics apply to the distribution and exchange of information goods.

Due to these differences does the ASP market exhibit a fundamentally different cost structure than the market for information goods and information services. The cost to develop an application service is very high (i.e., high fixed cost). This may involve the proper implementation of the software, or the licensing of an available solution from a third party provider (e.g., an independent software vendor). The cost to provide additional units of service is significant (i.e., non-negligible marginal cost). This is due to the additional per client and per unit of service cost experienced by the provider, as outlined above.

Economic models for pricing of information goods are therefore not directly applicable to pricing in the ASP market. Moreover, we think, that crucial decision variables for the

ASP market include the number of clients to service and the quantity of service to provide, while maintaining a controllable quality of service level. Both of these variables are not of major concern to providers of information goods

In the following we review common software distribution models, define further terminology, and refine the discussion of characteristics governing the ASP market. This serves to further motivate our assumptions underlying the economic model developed in the section thereafter.

### *2.1. Software licensing and software leasing*

We distinguish three main forms of software distribution. First, the *classical software distribution model* refers to the case where software is sold through a network of distribution channels to the end-user. The customer buys and installs the software on his or her machine and may use it indefinitely.

With *license-based software distribution* we refer to a refined model, whereby a customer buys and installs the software on his machines, but is bound through a contractual agreement to pay periodic (e.g., yearly) license fees to keep using the software. In return the customer receives updates, consulting, or new versions of the software. Variations of this model exist, but are of no further relevance to our present discussion, and have therefore been left out.[11]

Second, the *leasing-based software distribution model* refers to the scenario motivated in the introduction (a.k.a. ASP-model). In this model a customer interacts with an application over the network, with all management aspects of the hardware and the software being shifted to the ASP. Other leasing-based software deployment models exist.[12] However, in this paper we limit our discussion to the above defined ASP-model, deferring a more differentiated discussion to future work.

Finally, a combination of software licensing and application service providing is a further software distribution model that is emerging. In this model a firm licenses applications and offers complementary services over the network, for example, application administration, security management, performance monitoring, and data backup (cf. Buckmann (2000) for indications of trends in this direction.)

The ASP-model permits a fine-grained billing structure, and allows to charge a user on a pay-per-use basis, differentiable into various dimensions. In contrast, in classical software distribution and in software licensing a customer gets the entire functionality of an application, whether or not it is actually required. Consequently, billing is much coarser grained, only reflecting the versioning structure of the product.[13]

In the rest of this paper we will subsume the first two distribution models and refer to them simply as traditional software distribution model (and traditional software market), whereas to the latter as ASP-model (and ASP-market). In the following we will also refer to the traditional software distribution model as ISV-model (Independent Software Vendor) and ISV-market.

### 2.2. *The ASP market and its characteristics*

Due to the emergence of an ASP market customers face the choice between buying a software package or leasing an application service. Note, that in this latter case, a customers may do more than simply "lease" a software license, as the ASP might provide additional services (e.g., application maintenance, version management, and data back-up and recovery etc.), which are not provided in the traditional distribution model. Independent software vendors face strategic decisions of whether to license their applications to ASPs, what license agreements to engage in with ASPs, or whether to offer their applications as services themselves. Consequently, the ASP market and the classical software distribution market are strategically interconnected (i.e., decisions made in one market effect behavior and decisions made in the other market.)

Contrary to the ASP-model, it is commonly assumed and accepted that software distribution based, either on the traditional software distribution model, benefits from local monopoly. The main arguments sustaining this hypothesis rely on product differentiation strategies used by software vendors (for a detailed discussion of these aspects see Shapiro and Varian (1998) and Katz and Shapiro (1999).) Differentiated products mainly imply high switching costs for customers and generate network externality. In the ASP-model, products may be less differentiable, due to standards, open platforms, the potential use of intermediaries for data storage, data transformation and formatting services. Moreover, the application users are more in control of their data, as the data has to be transmitted to and from the service provider in an agreed upon format, or pass through several stages of processing at multiple third party providers.

This is further motivated by the lower switching cost bared by a customer in the ASP market (i.e., customer has neither to install the software, nor to bear the total cost of the full software license). The network externality associated with the use of specific software is sharply reduced as file exchange and data formatting can be facilitated through standards, intermediaries, and the fact that data must already pass from customer to ASP in an agreed upon format over the network. As a consequence, the ASP market is more competitive than the traditional software market. And due to the high concentration in the software industry—few firms providing the same product—it is reasonable to assume that the ASP market faces oligopolistic competition.

A further key difference of these two markets is the cost beard by the firms (ISV versus ASP) on the different markets. Whereas software application development imply high fixed costs (i.e., long software development cycle) and negligible marginal costs (copies of software are cheap to produce and Internet distribution of software allows to reduce marginal cost nearly to zero). In general, ASP activity implies similar fixed cost but higher marginal cost (such that cost associated with hosting a new client, i.e., administration overhead, additional penetration of help-desk, additional resource needs, etc.).

Strategic decisions faced by ASPs are thus the number of customers to support and the quantity of service to offer at an acceptable quality of service level. We assume that firms are in Cournot competition (i.e., they have to decide how many quantity of service they will deliver on the ASP-market).

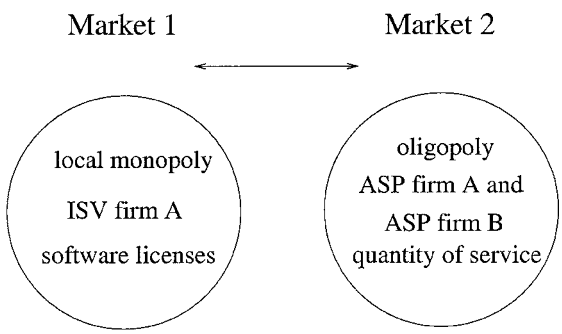


*Figure 1.* Abstract description of model involving players, markets, and products.

In the next section, we model the relationship between a software application vendor and an application service provider in two markets: the traditional software market (classical and license-based software distribution) and the ASP market and show how they interact. Figure 1 gives an abstract preview of the different markets, players, and products relevant to our model.

## 3. The economic model

The emerging ASP-model has two different kinds of implications on the traditional software market. On the one hand, a leased application is a more or less perfect *substitute* for the same application, deployed as a locally installed, licensed application (cf. our discussion in Section 1). As ASP firms also supply this market, the local monopoly which benefits the traditional ISV is endangered by these new activities. On the other hand, the leasing of applications provides additional *opportunity of profit* to the ISV, that can also lease its applications on the ASP-market.

In this section, we develop an economic model to capture the main implication of these two effects on ISV-market activity. In Section 3.1 we present the hypotheses of our model. In Section 3.2 we specify the implications of the economic structure developed in our model on the ISV firm activity, who acts on the ASP-market and on the ISV-market.

### *3.1. The model*

In our model, we consider two players, firm $A$ and firm $B$. Firm $A$ is involved in two different activities. First, it acts as an independent software vendor on market 1, where it sells software licenses. Second, firm $A$ is an application service provider on market 2, where it offers application services accessible via the network (e.g., Internet, or leased communication line).

On this latter market, firm $A$ competes with firm $B$, also an ASP in this market. Note, that firm $B$ performs only on market 2, where it leases applications. We assume Cournot competition in market 2. Under Cournot competition firms simultaneously choose their output, i.e., quantities of service delivered.

Products exchanged on these two markets are *software licenses* ($q_1^A$ for firm $A$ on market 1) and an homogeneous service named *standard units of service* ($q_2^A$ for firm $A$ and $q_2^B$ for firm $B$ on market 2). This quantity determines, for example, server resource utilization, duration of a connection to the ASP, or level of service requested (e.g., backup schedule: daily, weekly, monthly; hot-line: 24 hours, 8 hours).

More specifically, firm $A$ sells software licenses on market 1. The inverse demand function for this market is given by

$$p_1^A = a - q_1^A - e_R\big(q_2^A + q_2^B\big). \tag{3.1}$$

For market 2, the inverse demand function for firm $A$ and firm $B$ is given by

$$p_2 = b - q_2^A - q_2^B - e_R q_1^A, \tag{3.2}$$

where $a$ and $b$ denote the intercept of the demand functions ($a > b > 0$), and $e_R$ (with $e_R \in [0, 1]$) is a parameter that models the relationship between market 1 and market 2, such as the cross price elasticity of demand[14]. The parameter $e_R$ is always positive and provides a measure of the level of substitution between the product sold on market 1 and the service delivered on market 2. Note, that, when $e_R$ is zero, the two markets are independent. On the contrary, $e_R$ equals one means that the two products are perfect substitutes.

As discussed below, the cost associated with ISV-activities and ASP-activities can be differentiated. On the ISV-market, the first software license sold is very costly to produce (high fix cost). But once the first copy is developed, it can be reproduce at a constant and negligible cost (very low marginal cost). Assuming that the software licenses are distributed online, the ISV-activity implies no marginal cost. On market 1, firm $A$ costs are fix and equal to $F_1^A$. On the ASP-market, the provision of the service generates non-negligible marginal costs and may incure lower fix costs.

At this level, one has to distinguish between firm $A$ and firm $B$ cost structures. In effect, firm $A$ leases its own software on the ASP-market. Thus, all costs generated by the software development are already supported by the firm on the ISV-market. Firm $B$ faces a different situation and may either develop an application only available on the Internet (*case 1*) or buy licenses from firm $A$ on the ISV-market and lease the applications on the ASP-market (*case 2*). This latter case requires that the ASP can cut its costs by buying one piece of software for several customers.

Moreover, the production of each *standard unit of service* implies a marginal cost. We assume that the firms are symmetric (they use the same technology on market 2) and, for both firms, the return scale of the technology[15] is constant, i.e., $C(q_2^A) = \delta q_2^A$, with $0 \leqslant \delta \leqslant 1$, for firm $A$ and $C(q_2^B) = \delta q_2^B$ for firm $B$.

If firm $B$ develops and sells its own software application on the ASP-market, the fix cost of the firm $A$ and firm $B$ are $F_2^A$ and $F_2^B$, respectively, with $F_2^A < F_2^B$. And, the total cost functions of firm $A$ and firm $B$ are $C^A = F_1^A + F_2^A + \delta q_2^A$ and $C^B = F_2^B + \delta q_2^B$, respectively. The profit functions of firms $A$ and $B$ are given by

$$\pi_A = p_1^A q_1^A + p_2 q_2^A - F_1^A - F_2^A - \delta q_2^A \quad \text{and} \tag{3.3}$$

$$\pi_B = p_2 q_2^B - F_2^B - \delta q_2^B, \tag{3.4}$$

respectively. If firm $B$ buys licenses on the ISV-market, the fix costs of the two firms on the ASP-market are identical ($F_2^A = F_2^B$), but firm $B$'s marginal cost becomes a function of $p_1$, the price of software license sold on market 1. To produce one unit of service, firm $B$ needs $\varepsilon$ of a license with $0 < \varepsilon < 1$. Thus, the total cost function corresponds to $C^B = F_2^B + q_2^B(\varepsilon p_1 + \delta)$ and its new profit function is given by

$$\pi_B = p_2 q_2^B - F_2^B - q_2^B(\varepsilon p_1 + \delta). \tag{3.5}$$

The total cost function of firm $A$ is unchanged but it gets additional profits from its distribution of software licenses to firm $B$. Firm $A$'s new profit function is given by

$$\pi_A = p_1^A q_1^A + p_2 q_2^A + \varepsilon p_2 q_2^B - F_1^A - F_2^A - \delta q_2^A. \tag{3.6}$$

### *3.2. Multi-product oligopoly and economic structure*

In multi-product oligopoly, the demand for a product is related to the consumption and the prices of the other products. In order to specify such relations, we first determine under which conditions goods and services exchanged on ISV and ASP markets are complements or substitutes. Second, we adopt the point of view of firm $A$, which participates in the two markets, to consider the effect of the ISV and ASP activities on its total profit. Finally, we derive the strategic relations between firm $A$ and firm $B$'s decisions on the ASP-market.

***3.2.1. Relation between the products: Software licenses and ASP-services*** For products, the character of being a substitute is partially captured by measuring the cross-price elasticity of demand ($\epsilon_{(q_i,p_j)}$ with $i \neq j$) between the two products,

$$\epsilon_{(q_2,p_1)} = \frac{\partial q_2}{\partial p_1}\frac{p_1}{q_2} = \frac{e_R}{1-e_R^2}\left[\frac{a - q_1^A}{q_2^A + q_2^B} - e_R\right]. \tag{3.7}$$

Assuming that $e_R$ is positive and the two products are substitutes, the cross-price elasticity is positive ($\epsilon_{(q_2,p_1)} > 0$) which implies that $a - q_1^A > e_R(q_2^A + q_2^B)$. Therefore, an increase in $p_1$ has a positive impact on the ASP-market demand. In effect, the raise of software license prices makes the ASP-market more attractive.

A perfect substitute is a product that the customer regards as providing as much utility as an alternative one. In our case, the customer will either buy a software license or use the online application service provided by the ASP. It corresponds to the situation where two alternatives are available: selling or leasing the software. Note, that our hypothesis assumes that software license demand and ASP-service demand are equally affected by $e_R$. By varying $e_R$'s value, our model allows to account for different levels of substitution between licensing and leasing software ($e_R > 0$).

***3.2.2. The effects of multi-market activities*** Firm $A$'s implication on ISV-activities and ASP-activities has a direct influence on its total profit. Note, it doesn't benefit from joint economies or suffers of dis-economies because we assume that its marginal costs on market 1 and market 2 are unrelated (cf. Eq. (3.3)). As a consequence, the effect of market 1

*Table 1.* Profit differentiation to $q_2^B$ and $q_2^A$.

| | *Case 1* | *Case 2* |
|---|---|---|
| $\frac{\partial^2 \pi_A}{\partial q_2^B \partial q_2^A}$ | $-1$ | $-\varepsilon$ |
| $\frac{\partial^2 \pi_B}{\partial q_2^A \partial q_2^B}$ | $-1$ | $\varepsilon - 1$ |

and market 2 activities on firm $A$'s total profit is due to the connection between the two demand functions for ISV and ASP products. This situation is closely related to the substitute or complement character of products exchanged on these markets.

To evaluate the previous effect, we consider the result of an increase in the quantity $q_1^A$ and $q_2^A$ on firm $A$'s marginal total profit. We ask whether more aggressive strategies, such as raising sales, increases marginal total profit of the player. To answer this question we derive firm $A$'s total profit according to its decisions on both markets. For both *cases* we obtain the following results:

$$\frac{\partial^2 \pi_A}{\partial q_1^A \partial q_2^A} = -2e_{\mathrm{R}}. \tag{3.8}$$

The two markets are negatively interrelated (i.e., $e_{\mathrm{R}} > 0$), therefore the two products (software licenses and ASP) are substitutes. Firm $A$ competes with firm $B$ on the ASP-market and quantities of services delivered on this latter market erode firm $A$'s monopoly power on the ISV-market. Then, being more aggressive in one market (raising sales) lowers the marginal total profits from being a little more aggressive on the other market.

***3.2.3. Strategic relation between competitors' decisions*** Here, we define the strategic relation between the firms' decisions on the ASP-market. We assumed that services offered on market 2 are identical, and the customers are indifferent between firm $A$'s and firm $B$'s services. Following the terminology introduced by Bulow et al. (1985) Table 1 shows that the decisions of the two firms are strategic substitutes.

The equations, reported in Table 1, determine the effect of an increase in the quantities of service delivered on the ASP-market ($q_2^B$ and $q_2^A$) on firm $A$'s and firm $B$'s marginal total profit. In both cases, the two derivatives are negative. Thus, firm $A$ (frim $B$) regards its product on market 2 as a strategic substitute to firm $B$'s (firm $A$'s). Therefore, with strategic substitute the optimal strategy of firm $B$ to a more aggressive play (increase of its quantities) of firm $A$ is to be less aggressive (reduce its quantities). The reaction curve of the two firms are downward sloping (see Figure 2 for an illustration). Therefore, a more aggressive strategy of firm $i$ (with $i = A, B$) lowers firm $j$'s (with $i \neq j$) marginal profit from being more aggressive in the ASP-market (i.e., an increase in $q_2^B$ ($q_2^A$) lowers firm $A$'s (firm $B$'s) total profit $\pi_A$ ($\pi_B$)).

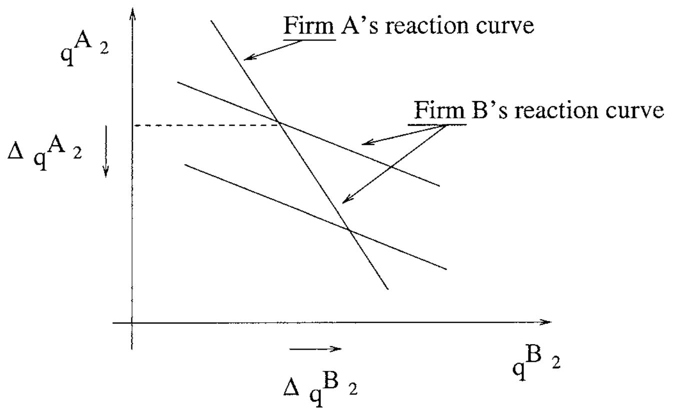


*Figure 2.* Firm $A$'s and firm $B$'s reaction curves with strategic substitutes.

*Table 2.* Firm $A$'s and firm $B$'s reaction functions.

| | *Case 1* | | *Case 2* | |
|---|---|---|---|---|
| | $q_2^A > 0$ | $q_2^A = 0$ | $q_2^A > 0$ | $q_2^A = 0$ |
| $q_1^A(q_2^A, q_2^B)$ | $\frac{a - e_R(2q_2^A + q_2^B)}{2}$ | $\frac{a - e_R q_2^B}{2}$ | $\frac{a - e_R(2q_2^A + (1+\varepsilon)q_2^B)}{2}$ | $\frac{a - e_R(1+\varepsilon)q_2^B}{2}$ |
| $q_2^A(q_1^A, q_2^B)$ | $\frac{b - 2e_R q_1^A - q_2^B - \delta}{2}$ | 0 | $\frac{a - 2e_R q_1^A - (1+\varepsilon)q_2^B - \delta}{2}$ | 0 |
| $q_2^B(q_1^A, q_2^A)$ | $\frac{b - e_R q_1^A - q_2^A - \delta}{2}$ | $\frac{b - 2e_R q_1^A - \delta}{2}$ | $\frac{(1-\varepsilon)(a - q_2^A - e_R q_1^A) - \delta}{2(1-\varepsilon)}$ | $\frac{(1-\varepsilon)(a - e_R q_1^A) - \delta}{2(1-\varepsilon)}$ |

## 4. Theoretical predictions

From the model, we derive the reaction functions of firm $A$ and firm $B$ on the two markets which are reported in Table 2. These functions correspond to the best response of each firm to its opponent's decisions. We verify that for substitute products, $q_2^B(q_1^A, q_2^A)$ and $q_2^A(q_1^A, q_2^B)$ are decreasing function in $q_1^A$; and, that $q_1^A(q_2^A, q_2^B)$ is also a decreasing function in $q_2^A$ and $q_2^B$. In Table 3 one must differentiate the cases for which firm $A$ decides ($q_2^A > 0$) to supply or not to supply ($q_2^A = 0$) the ASP-market. Note that, if none of the firms takes part in the second market, the customer can only buy software licenses from firm $A$ which supplies the usual monopoly quantities on market 1 (i.e., $q_2^A = a/2$). If firm $A$ is the only firm to supply the two markets its reaction function is identical in the two cases and corresponds to $q_1^A(q_2^A, q_2^B) = a/2 - e_R q_2^A$ on market 1 and to $q_2^A(q_1^A, q_2^B) = (b - \delta)/2 - e_R q_1^A$ on market 2. At the equilibrium, $q_1^{A*}$ and $q_2^{A*}$ are given by

$$q_1^{A*} = \frac{e_R(b - \delta) - a}{2(e_R^2 - 1)} \quad \text{and} \quad q_2^{A*} = \frac{\delta - b + a e_R}{2(e_R^2 - 1)},$$

respectively.

*Table 3.* Equilibrium quantities $q_1^{A*}$, $q_2^{A*}$ and $q_2^{B*}$ in *case 1* and *case 2*.

| | *Case 1* | | *Case 2* | |
|---|---|---|---|---|
| | $q_2^{A*} > 0$ | $q_2^{A*} = 0$ | $q_2^{A*} > 0$ | $q_2^{A*} = 0$ |
| $q_1^{A*}$ | $\frac{e_R(b-\delta)-a}{2(e_R^2-1)}$ | $\frac{e_R(b-\delta)-2a}{e_R^2-4}$ | $\frac{e_R(b-\delta)-a}{2(e_R^2-1)}$ | $\frac{e_R(b(\varepsilon+1)-\delta))-2a}{2(e_R+\varepsilon)}$ |
| $q_2^{A*}$ | $\frac{3ae_R}{2(e_R^2-1)} + \frac{(\delta-b)(e_R^2-2)}{2(e_R^2-1)}$ | 0 | $\frac{e_R^2(\delta(\varepsilon-1)+b(\varepsilon+1))}{(\varepsilon-1)(\varepsilon-3)(-1)} + \frac{2(b(\varepsilon-1)-\delta)+ae_R(\varepsilon-3)}{(\varepsilon-1)(\varepsilon-3)(e_R^2-1)}$ | 0 |
| $q_2^{B*}$ | $\frac{(b-\delta)}{3}$ | $\frac{ae_R+2(\delta-b)}{e_R^2-4}$ | $\frac{\varepsilon(b+\delta)-b+\delta}{(1+\varepsilon)(\varepsilon-3)}$ | $\frac{(e_Ra-2b)(1+\varepsilon)+2\delta}{(1-\varepsilon)(e_R^2(1+\varepsilon)+4)}$ |

In Cournot game, firm $A$ and firm $B$ choose simultaneously their equilibrium strategies on market 1 and market 2. At the equilibrium, we obtain the best reply of firm $i$ to the best reply of firm $j$, with $i = A, B$ and $i \neq j$. The resulting Nash equilibrium give us the quantities delivered on each market, the number of software license in market 1 and the total units of ASP-service online in market 2. For both of cases studied, $q_1^{A*}$, $q_2^{A*}$, $q_2^{B*}$ represent the equilibrium quantities offered on market 1 and market 2 by each firm, respectively. These equilibrium quantities, presented in Table 3, are functions of $e_R$ in *case 1* and of $\varepsilon$ in *case 2*.

Assuming $0 < e_R < 1$, $\delta = 20$, $a = 200$, and $b = 150$, the cross elasticity of the demand function is always positive on the interval $e_R \in [0; 1[$. Therefore, in our two cases, the software licenses and unit of service delivered on the ASP-market are always substitutes; i.e. if the price of standard unit of service increase on the ASP-market, the demand for software licenses increase.

For the given parameters, Figures 3 and 4 represent the equilibrium quantities delivered, in *case 1* on market 1 ($q_1^{A*}$) and on market 2 ($q_2^{A*}, q_2^{B*}$) by firm $A$ and firm $B$ (firm $B$ quantities are identified by the dotted line). At the equilibrium, the number of licenses delivered on market 1, $q_1^{A*}$, and the quantities of services delivered on market 2, $q_2^{A*}$, are two decreasing functions in $e_R$. When the connection between the two markets is sufficiently large ($e_R > 0.64$ in our example for *case 1*), firm $A$ focus its activity exclusively on the ISV-market (i.e., distribution of software licenses). On the opposite, firm $B's$ offer is independent of $e_R$, if firm $A$ competes on the ASP-market. Once, it is the only supplier but it has to compete indirectly with firm $A's$ ISV-activity on market 1. The higher the level of substitution between the leased application and the licenses application, the higher is this indirect competition. As a consequence, its offer becomes also a decreasing function in $e_R$.

If firm $A$ acts as a competitor on the ASP-market, firm $B's$ offer is independent of $e_R$ (see Figure 4 where the dotted lines represent the equilibrium values for $\varepsilon = 0.2$ and the solid curves for $\varepsilon = 0.8$)). When the connection between the two markets is sufficiently large ($e_R > 0.48$ in our example for *case 1*), firm $A$ focus its activity exclusively on the ISV-market (i.e., distribution of software licenses). In that latter cases, firm $B$ competes indirectly with firm $A$'s ISV-activity on market 1. Then, the higher the level of substi-

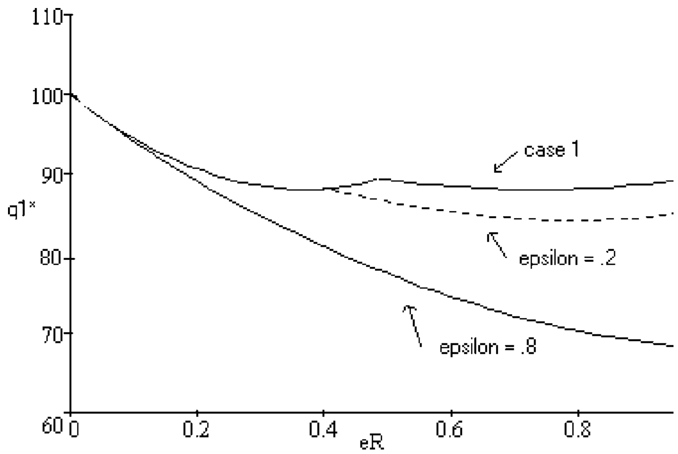


*Figure 3.* Quantity $q_1^{A*}$ in *case 1* and *case 2*.

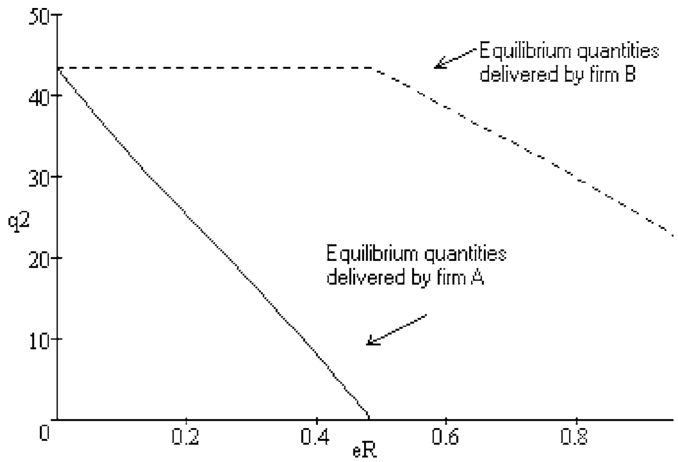


*Figure 4.* The equilibrium quantities $q_2^{A*}$ and $q_2^{B*}$ offered on market 2 in *case 1*.

tution between the leased applications and the licenses ones, the stronger is the indirect competition. As a consequence, firm $B$ offer becomes also a decreasing function in $e_{\mathrm{R}}$.

In *case 2*, we focus on the effect of parameter $\varepsilon$ on the equilibrium offers. We specify the combination of $\varepsilon$ and $e_{\mathrm{R}}$ for which firm $A$ supplies, at the equilibrium on market 2. The gray part in Figure 5 indicates the area where $q_2^{A*}$ is strictly positive. For these value combinations, firm $B$ offers are constant in $e_{\mathrm{R}}$ but increase with $\varepsilon$. For higher value combinations, $q_2^{A*}$ equals zero and firm $B$ is the only actor on market 2. Being in indirect competition with firm $A$, its equilibrium offer decreases in $e_{\mathrm{R}}$. In order to simplify our discussion, we run a simulation for a low and a higher level of $\varepsilon$ ($\varepsilon = 0.2$ and $\varepsilon = 0.8$). The use of the same parameter values ($a$, $b$ and $\delta$) will allow us to compare the two cases.

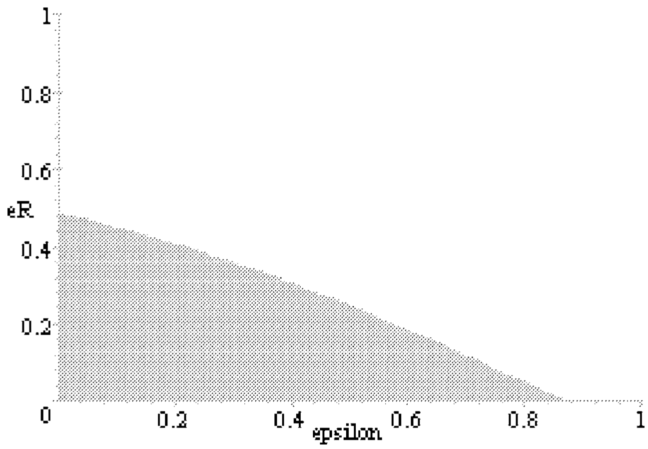


*Figure 5.* Firm $A$ participation in market 2.

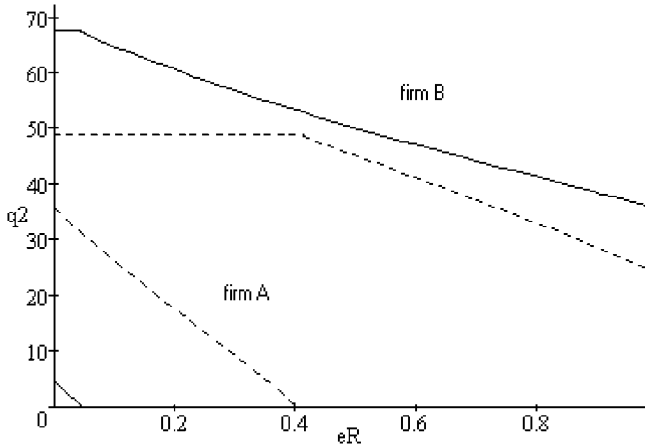


*Figure 6.* Quantities $q_2^{A*}$ and $q_2^{B*}$ in *case 2*.

Figure 6 presents equilibrium quantities $q_2^{A*}$ and $q_2^{B*}$ delivered on market 2 as a function of $e_{\mathrm{R}}$. The dotted curves correspond to the situation with $\varepsilon = 0.2$ and the solid curves to $\varepsilon = 0.8$. Note that *case 1* can be interpreted has a special situation for which $\varepsilon = 0$. If firm $B$ needs a high share of software licence ($\varepsilon = 0.8$) to produce services on the ASP-market, it offers a bigger quantity of services at the equilibrium than for $\varepsilon = 0.2$. The model predicts the opposite behavior for firm $A$. The higher $\varepsilon$, the lower the connection between the two markets, $e_{\mathrm{R}}$, is required by firm $A$ to not supply the ASP-market.

From equilibrium quantities ($q_1^{A*}$, $q_2^{A*}$, and $q_2^{B*}$), we derive equilibrium prices, $p_1^*$ and $p_2^*$, for market 1 and market 2 which are reported in Table 4.

Over the interval $e_{\mathrm{R}} \in [0, 1[$, the equilibrium prices on market 1, $p_1^*$, are rather stable in both cases and in $\varepsilon$ values (see Figures 7 and 8). Equilibrium prices on market 2,

*Table 4.* Equilibrium prices $p_1^*$ and $p_2^*$ in *case 1* and *case 2*.

| | *Case 1* | | *Case 2* | |
|---|---|---|---|---|
| | $q_2^{A*} > 0$ | $q_2^{A*} = 0$ | $q_2^{A*} > 0$ | $q_2^{A*} = 0$ |
| $p_1^*$ | $\frac{e_R(\delta - b) + 3a}{6}$ | $\frac{e_R(b-\delta) - 2a}{(e_R^2 - 4)}$ | $\frac{a((\varepsilon+2)^2 - 1)}{2(\varepsilon - 3)(1+\varepsilon)} - \frac{e_R(\delta(\varepsilon-1)^2 + b(1-\varepsilon^2))}{2(\varepsilon-3)(1+\varepsilon)}$ | $\frac{a(\varepsilon+1)(e_R^2\varepsilon - 2)}{(\varepsilon+1)(e_R^2(1+\varepsilon)-4)} + \frac{e_R(\delta(\varepsilon-1)+b(1-\varepsilon^2))}{(\varepsilon+1)(e_R^2(1+\varepsilon)-4)}$ |
| $p_2^*$ | $\frac{b+2\delta}{3}$ | $\frac{e_R(a - \delta e_R) - 2(b+\delta)}{(e_R^2 - 4)}$ | $\frac{-b(1+\varepsilon) - 2\delta}{(\varepsilon-3)(1+\varepsilon)}$ | $\frac{(\varepsilon+1)(\delta e_R^2 + a e_R - 2b) - 2\delta}{(\varepsilon+1)(e_R^2(1+\varepsilon)-4)}$ |

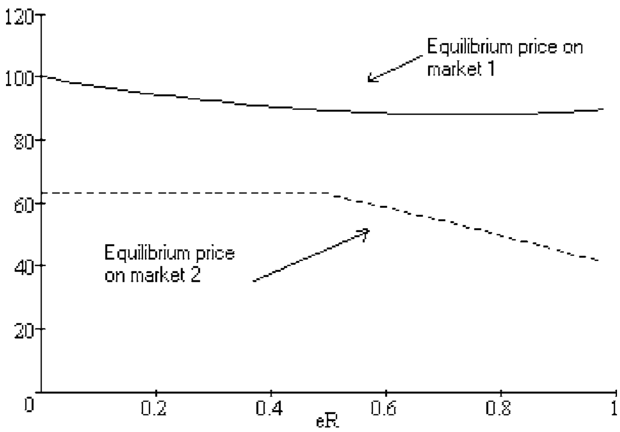


*Figure 7.* Equilibrium prices $p_1^*$ and $p_2^*$ on market 1 and market 2 in *case 1*.

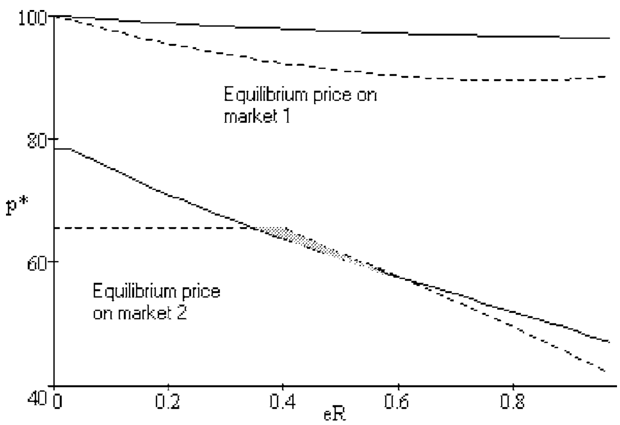


*Figure 8.* Equilibrium prices $p_1^*$ $p_2^*$ on market 1 and market 2 in *case 2*.

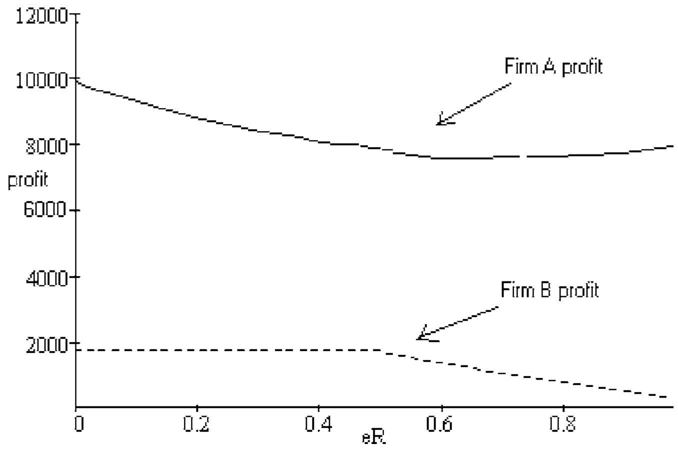


*Figure 9.* Equilibrium profit on market 1 and market 2 in *case 1*.

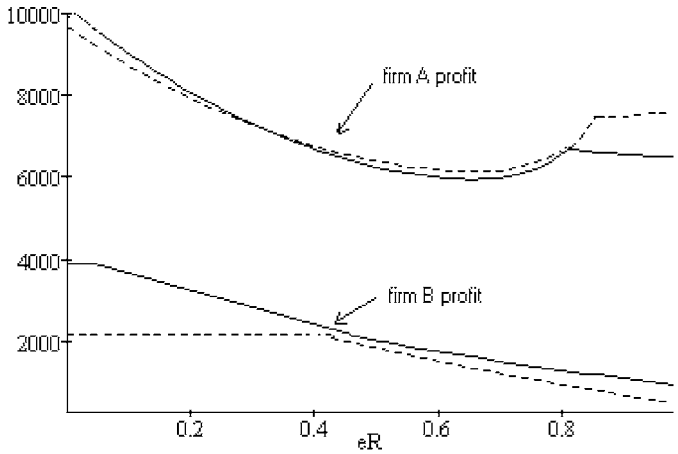


*Figure 10.* Equilibrium profit on market 1 and market 2 in *case 2*.

$p_2^*$, depend dramatically on $q_1^{A*}$ and $q_2^{A*}$. If $q_2^{A*} > 0$, in both cases $p_2^*$ is constant in $e_{\mathrm{R}}$, whereas $p_1^*$ slightly decreases in $e_{\mathrm{R}}$. If firm $B$ is the only active firm on market 2, it competes indirectly with firm $A$, which produces only software licenses. Therefore, the equilibrium prices on market 2 decreases as $e_{\mathrm{R}}$ increases. In *case 2*, $p_2^*$ depends also on $\varepsilon$, the share of licenses that firm $B$ needs to produce for one unit of service. For high values of $\varepsilon$, $p_2^*$ decreases sharply with $e_{\mathrm{R}}$ such that it can be lower than $p_2^*$ with lower $\varepsilon$ values (see the gray part in Figure 7). This last results is due to the sharp decline in $q_1^{A*}$ and $q_2^{B*}$. The equilibrium prices are lower in *case 1* than in *case 2*.

Finally, the equilibrium profit comparison will allow to compare *case 1* and *case 2* from firm $A$'s and from firm $B$'s point of view. Figures 9 and 10 represent the equilibrium profit of firm $A$ and firm $B$ as a function of $e_{\mathrm{R}}$ for both cases.

For all $e_R$ values, the more profitable situations for firm $A$ is when firm $B$ decides to develop its own software. But this former statement is not true for firm $B$ which prefers, in all situations, to buy software licences from firm $A$. In *case 2*, for low connection between the two markets (i.e., small values of $e_R$) both firms make higher profit, if $\varepsilon$ is high. This is due to the fact that firm $A$'s offer on the ASP-market is rather low which implies higher equilibrium prices and, as a consequence, higher profit for firm $B$. For higher values of $e_R$, firm $A$'s equilibrium profit is higher, if $\varepsilon$ is low because it increases its sales of software licenses (see Figure 3).

## 5. Related work

To the best of our knowledge, the relationship between actions in two markets, for the distribution of software licenses in one market, and the competitive distribution of application services in a second market, has not been addressed previously.

Pricing models for the Internet have been studied extensively, e.g., (Fishburn and Odlyzko, 1998; Noll, 1997). Internet pricing, however, focuses on charging a user for a quality of service guarantee for the communication, but not for the use of a computational service or content delivered, more in scope of our work. Pricing strategies for information service intermediaries in monopolistic markets have been investigated by Bhargava et al. (1999). Strategic product differentiation for selling versus renting of software in a monopolistic market have been investigated by Choudhary et al. (1998). The main focus of our work lies on the interaction between markets and takes multi-player competition into consideration.

## 6. Discussion

Independent software vendors face important strategic decisions, due to the emerging ASP-software distribution model concerning pricing of software products, variable licensing models, partnerships, and strategic alliances. The economic model developed in this paper underlines some of the complex interrelations between the traditional software market, based on *licensing* software applications, and the emerging ASP-market, based on *leasing* software applications. The model captures a *selling versus leasing software distribution* scenario. The crucial point relates to the level of differentiation between the two produces exchanged on the ISV-market and the ASP-market captured through the variable $e_R$—the degree of substitution between two products. In that framework two economic situations have been investigated. Either, firm $B$ develops its own application to lease on market 2 or it decides to buy software on market 1 to lease on market 2.

Our main results is that, the introduction of competition lower the prices of the software licenses as well as the price of the ASP services. The lower equilibrium prices are obtained in *case 1*, when firm $B$ decides to develop its own applications to lease. Nevertheless firm $B$ prefers to buy licenses on the ISV-markets (*case 2* is preferred to *case 1*). For low connection between the markets (i.e., $e_R$), a high value of $\varepsilon$ is preferable for the two firms which specialized on one of the two activities. Firm $A$ sells licenses and firm $B$ leases applications on the ASP-market. For high market connection, a "conflict" appears between the two firms. Contrary to firm $A$ which prefers low value of $\varepsilon$, firm $B$ profit are higher when $\varepsilon$ is high because of the sharp decrease in license software supply on the ISV-market.

This paper attempts to develop a simplified model to described the implications of traditional software application distribution on ASP activities. Further direction of research will involve a dynamic rather than a static model to capture the effects of ASP activities on software application distribution on several periods. In the framework of our model, we also plan to integrate the relation between the products, $e_{\mathrm{R}}$, as a strategic variable. Endogenous $e_{\mathrm{R}}$ will allow us to take the strategic development of ASP services delivered on the market into account.

## Notes

1. E.g., www.strato.de.
2. E.g., www.uunet.com.
3. E.g., www.exodus.com.
4. E.g., www.olsen.ch.
5. E.g., www.olsen.com (email), www.siennax.com (document).
6. ERP is a general term that refers to a customizable software package that captures a firms (mostly internal) business processes and offers software solutions for its management.
7. E.g., www.qmacs.com
8. Many ERP systems offer standard solutions that do not require lengthy mapping of the customer's business model into the ERP system model. The expectation is that these standard solutions suffice most small and medium size firms. Moreover, the trend in this field is towards standardization of business processes and componentization of applications implementing standard business processes (Sprott, 2000).
9. Functional substitute products do already exist.
10. E.g., www.citrix.com.
11. Software license agreements are often designed according to the number of users using an application (i.e., per-seat), or according to the numbers of clients interacting with an application, or per application clients and per application servers deployed. In our discussion we subsume these finer grained licensing structures in this category.
12. The leased software could run entirely on the customer's machines and be managed remotely by the ASP, or part of the application could run on the customer's machine and part on a remote server farm.
13. A customer may, for instance, chose between a *demo*, a *student*, an *advanced*, and a *professional* version.
14. Cross-price elasticity of demand refers to the percentage change in the quantity demands for a good that results from a one percent increase in the price of another good. If cross-price elasticity is positive then, goods are substitutes, and if cross-price elasticity is negative then, goods are complements.
15. Constant returns scale technology means that the production cost of each additional unit of service delivered on the ASP-market is constant.

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**Nadège Marchand** is currently a postdoctoral visitor at the Center for Inter-University Research and Analysis on Organizations (CIRANO) in Montréal, Canada.

Dr. Marchand's research focuses on strategic interactions and their connections with bargaining games, dynamic choices, learning processes and incentive designs. She uses experimental economics to investigate and develop economic models in this context.

In 2000, she worked at the Institute for Economic Theory III at Humboldt University in Berlin, Germany. She was sponsored through a TMR (Training and Mobility for Research) fellowship of the European Network for the Development of Experimental Economics and its Application to Research on Institutions and Individual Decision Making (ENDEAR). At the same time she also participated in the TMR program on Saving and Pension.

In December 1999 she completed her Ph.D. in economics at the University of Lyon 2 in France, working at the Institute of Economic Theory and Analysis (GATE UMR), part of the French national scientific research center (CNRS).

Her doctoral dissertation entitled, “Ultimatum and the Economic Rationale of Bargaining: An Experimental Approach”, emphasizes the experimental analysis of sequential bargaining games and bargaining strategies used by participants when one introduces competitive pressure in the strategic environment.

**H.-Arno Jacobsen** holds a faculty position with the Department of Electrical and Computer Engineering and the Department of Computer Science at the University of Toronto. His principal areas of research include middleware systems, distributed systems, and electronic commerce systems. Prior to moving to Toronto, he spent one year as a post-doctoral fellow, supported by a scholarship awarded through the European Community, with the Distributed Database Research Group at INRIA-Rocquencourt in France.

H.-Arno Jacobsen received his Ph.D. degree with highest honors (summa cum laude) from the Institute of Information Systems, Humboldt University, Berlin, in 1999. His research was sponsored by a doctoral fellowship awarded by the German Research Foundation for participation in the graduate program on “Distributed Information Systems” in Berlin. His research was honored with the annual IBM Best Paper Award and his dissertation was awarded with the Humboldt Price.

Prior to his doctoral research, Arno Jacobsen worked for over three years in research laboratories in the US, including the International Computer Science Institute (ICSI) in Berkeley and the Lawrence Berkeley National Laboratory (LBNL). He received his M.S. Degree in computer science from the University of Karlsruhe, Germany, in 1995. During his undergraduate studies, Arno Jacobsen participated in various exchange student programs, visiting the Computer Science Department at the University of California, Berkeley, the Institute of Applied Mathematics in Grenoble, France, and the Department of Psychology at the University Louis Pasteur in Strasbourg, France.

Dr. Jacobsen is actively involved in the standardization activities of the Object Management Group (OMG), where he initiated and chairs the working group on “High Performance CORBA.” This working group is pursuing the extension of the CORBA middleware standard to include high-performance end-systems, such as needed for supporting CORBA applications on Web server farms, on scalable electronic commerce servers, and transaction processing systems. He has served as program committee member for numerous International conferences and workshops.