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# The Effect of Bargaining Power on Fixed Price IT Outsourcing Decisions

by

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# THE EFFECT OF BARGAINING POWER ON FIXED PRICE IT OUTSOURCING DECISIONS

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**Abstract**

*Successful IT outsourcing is usually for the benefit of both parties: the outsourcing client and the service provider. With a fixed price contract, the client tries to lower project risks and costs by transferring parts of a project to the service provider at a previously negotiated price. In this paper, we elaborate a model from the client's perspective to identify a project's optimal degree of outsourcing, considering both, costs and risks of software development. We then study the effect of bargaining power on this decision. Against the expectation that a powerful service provider demanding a higher price will cause a lower degree of outsourcing, the model shows that bargaining power has no effect on the decision. Instead, the client will choose the outsourcing degree at the maximum price spread between the service provider's cost and the development cost of the client, no matter how the benefit will be shared among the two parties.*

**Keywords:** IT-Outsourcing, Risk/Cost Valuation, Game Theory, Decision Theory

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## *Introduction*

According to Lacity and Hirschheim (1993) firms pursue outsourcing strategies to reduce costs and mitigate risks associated with their business processes. Increased competition forces companies to deal with the cost cutting that is necessary to stay in business. Therefore, the market for outsourcing services increased significantly over time and is about to outgrow previous prospects (Aspray et al. 2006). Especially software development projects are affected, in consideration of the fact that today software development skills are global commodities (Dutta and Roy 2005; Lacity and Willcocks 2003).

The Standish Group reports that still two thirds of IT projects fail or miss their targets (Standish Group 2009). Sauer et al. (2007) illustrate that when project risks are managed by a capable team, follow reasonable plans and tactics, and are of a manageable size, the outcomes are far better. To meet the desired requirement of making a project manageable, a project partitioning between a company and a service provider can be effective. Through outsourcing, projects can be managed more successfully (Slaughter and Ang 1996). IT service providers benefit from these developments and become more specialized and competitive (Currie 2000).

In this paper, we narrow our focus to fixed price outsourcing contracts, which can be used to transfer project risk and costs to a service provider for a previously negotiated price. We provide a formal-deductive model based upon decision theory and game theory that enables companies to determine an optimal outsourcing strategy by considering costs and risk of the project as well as the bargaining power of both parties.

Our research questions are: *1) Which degree of outsourcing should a client choose to minimize the risk adjusted costs of a software development project? 2) How does bargaining power affect this decision?*

### *Literature Overview*

IT outsourcing is defined as the decision on relocating an IT department's tasks to a third party vendor, who conducts them and charges a certain fee for the service (Apte et al. 1997; Lacity and Hirschheim 1993; Loh and Venkatraman 1992). The reasons for IT outsourcing are manyfold, e.g. Di Romualdo and Gurbaxani (1998) identified three strategic intents for IT outsourcing, in particular IS improvement, business impact, and commercial exploitation. But the main motive is cost reduction (Dibbern et al. 2004; Lacity and Willcocks 1998; Standish Group 2009). Based on industry data, Han et al. (2005) show that outsourcing contributes positively to economic growth. To realize benefits on a company level, firms need a strategy to manage the costs and risks of outsourcing decisions (Nault 1997; Willcocks et al. 1999). In recent years, instead of closing "outsourcing megadeals" selective outsourcing evolves, where companies decide deliberately on their outsourcing activities (Lacity et al. 1996). An integrated view of outsourcing, containing strategic, economic and social aspects, helps firms to realize the anticipated gains (Lee et al. 2003). Aron et al. (2005) coin the term "rightsourcing", which means that a conscious risk and relationship management with multiple outsourcing vendors enables companies to reap benefits. Besides the cost and efficiency advantages from IT outsourcing, drawbacks have to be taken into account when deciding on outsourcing. Outsourcing can entail disadvantages like unauthorized knowledge transfer, inflexibility though long term contracts, poor relationship management and accompanying poor loyalty and quality (Bryce and Useem 1998). These drawbacks must be included into the evaluation of outsourcing decisions. The costs and risks of outsourcing need to be assessed carefully (Dewan et al. 2007). Different methods of estimating development costs are discussed in Boehm et al. (2000). The estimation of the associated risk is equally important. Many articles focus on the qualitative assessment of risk, for example Aron et al. (2005) and

Willcocks et al. (1999), whereas few focus on the quantification and computation of risk, like Aubert et al. (1999).

Outsourcing clients and service providers bargain on outsourcing contracts. As Gopal et al. (2003) evinced, the bargaining power has an influence on the type of contract. Since clients favor fixed price contracts in contrast to vendors who prefer time-and-materials contracts, a more powerful client might assert a fixed price contract, whereas a more powerful vendor might force through a time-and-materials contract. In a recent study Gopal and Koka (2010) find that there are many project settings where the vendor might also prefer fixed price contracts over the time-and-materials contracts. Susarla et al. (2010) analyze the role of ex ante contract design and develop strategies to overcome underinvestment in IT outsourcing. The profit sharing between the outsourcing client and the vendor is also dependent on bargaining power (Dey et al. 2010). Supplementary to these effects we examine the influence of bargaining power on the degree of outsourcing within a fixed price outsourcing contract. We provide an economic model that delivers relevant insights supporting the design of outsourcing decision processes in today's business.

***Model***

Our focus is on the analysis of a situation where an outsourcing client tries to minimize the risk adjusted total costs generated by a certain IT project. For reasons of simplicity, we consider the outsourcing client's cash inflows to be independent from whether fractions of the projects are outsourced or not, so we focus on costs of outsourcing only. We model outsourcing as a fixed price and thus risk-free alternative for project development. Thereby, we define risk as a negative or positive deviation from an expected value. This corresponds to a business setting where a contract between outsourcing client and vendor assures characteristics and price of the service.

By outsourcing a fraction of a software development project at a fixed price, the associated risk (according to our definition) can be transferred to the vendor. Fridgen and Müller (2009) already described this effect and how it can be used to lower the risk adjusted costs of an IT project portfolio to a minimum.

The client has to decide on the fraction that is outsourced to the IT service provider. The size of an outsourced fraction, which we refer to as outsourcing degree, is our decision variable. We only consider development activities which can be outsourced. Essential project phases, which have to be accomplished internally, are not taken into account.

For a better understanding, we provide a rough overview over the influencing parameters in Table 1, before we start specifying our assumptions.

**Table 1. Overview of the Setting**

| | Outsourcing Client | Service Provider |
|---|---|---|
| Risky costs | • Costs of the internally developed project fraction | • Costs of the project fraction developed on behalf of the client |
| Risk-free costs | • Price for the externally developed project fraction<br>• Transaction costs | • none |
| Sum | • A project's risk adjusted costs | • Costs of the project fraction developed on behalf of the client |
| Cash inflow | • Cash inflow of a project | • Price for externally developed fraction of a project |

To distinguish the parameters of the two parties, we introduce $n$ as a subscript representing internal, client-related variables and $x$ as a subscript representing external, service provider-related variables. Therefore, the costs of the entire project are $C_n$ for internal development at the client's responsibility and $C_x$ for external development at the service provider's responsibility. As stated above, the costs caused by a certain project are risky. To model this situation, we make the following simplifying assumption 1:

**Assumption 1 -** *$C_n$ and $C_x$ are normally distributed, i.e. $C_n \sim N(\mu_n, \sigma_n^2)$ and $C_x \sim N(\mu_x, \sigma_x^2)$.*

Therefore, a project features certain expected costs (e.g. $\mu_n = \$\ 2\ Mio$ for internal development, $\mu_x = \$\ 1.8\ Mio$ for external development) and a certain positive or negative derivation from these expected costs (e.g. $\sigma_n = \$\ 40{,}000$ for internal development, $\sigma_x = \$\ 50{,}000$ for external development).

To decide under which conditions an outsourcing agreement is advantageous for the parties involved, we have to model the pricing of the outsourced project. The boundaries for this price assessment are determined by the client's and the provider's decision rules, which are specified by their respective risk adjusted costs as described in assumption 2:

**Assumption 2 -** *The risk adjusted costs are measured by both parties and follow the general structure $\Phi = \mu + \alpha\sigma^2$ with $\mu$ denoting the expected value of the costs, $\sigma$ denoting its standard deviation. We define $\alpha > 0$ as the parameter of risk aversion. The outsourcing client and the service provider are risk-averse regarding costs. The risk adjusted costs of the outsourcing client shall be minimized.*

The risk adjusted costs correspond to a preference function which is developed according to established methods of decision theory and integrates an expected value, its deviation, and the decision maker's risk aversion. This preference function is based upon the utility function $U(x) = -e^{2\alpha x}$ and due to assumptions 1 and 2 compatible to the Bernoulli principle (Bernoulli 1954). Its Arrow-Pratt characterization of absolute risk aversion (Arrow 1971) is $-2\alpha$ with $\alpha > 0$ modeling a risk-averse decision maker. The Arrow-Pratt characterization itself is negative because we model costs, not returns. A related model has been developed by Freund (1956). It was applied in similar contexts over the last decades, for example by Hanink (1985), Zimmermann et al. (2008) and Fridgen and Müller (2009). According to assumption 2, the risk adjusted costs of an entire project follow the structure $\Phi_n = \mu_n + \alpha_n\sigma_n^2$ for the outsourcing client and $\Phi_x = \mu_x + \alpha_x \sigma_x^2$ for the service provider, respectively. Risk adjusted costs can be interpreted as the expected costs plus a premium for the borne risk (variance) which is weighted by the respective parameter of risk-aversion.

For reasons of simplicity and to be able to identify an efficient outsourcing degree, we state the following assumption 3:

**Assumption 3 -** *A project is infinitely divisible between internal and external development. Every fraction of a project is perfectly correlated to every other fraction. Equal sized fractions of a project carry the same risk.*

Due to recent developments in computing concepts, like service oriented architectures, software development becomes more rapid, competitive, transparent and flexible. Therefore, the assumption of divisibility, or at least a convergence to infinite divisibility, is justifiable. For example Zimmermann et al. (2008) make an analogous assumption.

As a consequence of assumption 3 there is a proportional relationship between the volume of a project's fraction and the costs and associated risks, respectively. This implies that the larger a considered fraction of a project, the higher the costs of development and the higher the associated standard deviation. This is obviously simplifying matters, as different phases of software projects naturally carry different risk and costs (Conrow and Shishido 1997). Nevertheless, a differentiation between project phases goes beyond the scope of this paper and is subject to further work in this area.

To identify the optimal degree of outsourcing, we define the decision variable $\lambda \in [0,1]$, as percentage of a project's costs that refers to external development (at the service provider's responsibility). Therefore, $(1 - \lambda)$ is the percentage of a project's costs that refers to internal development (at the outsourcing client's responsibility). The outsourcing degree $\lambda = 1$ stands for a project that is developed completely externally, $\lambda = 0$ for a project that is developed completely internally.

If a fraction of a project is outsourced to an IT service provider, transaction costs occur. These are for example costs of communication and coordination (Aubert et al. 2004). For reasons of simplicity we only consider transaction costs that are linearly dependent on the fractions' size. Therefore, we state the following assumption 4:

**Assumption 4 -** *When a project is outsourced to a service provider with an outsourcing degree $\lambda > 0$, risk-free variable transaction costs $K(\lambda) = \lambda f$ occur to the client.*

As we take the client's perspective we omit explicitly modeling the service provider's transaction costs in this paper. They can be seen as part of the service provider's expected costs.

Besides the transaction costs, the externally developed fraction causes costs for the outsourcing client in terms of a price $P(\lambda)$ that the service provider demands from the client for the service offered. The service provider and the client agree on this price, as well as on all specifications of the service, by contract.

**Assumption 5 -** *The service's characteristics and quality, as well as a certain price, are contractually assured and carry no risk for the client.*

Please note that this assumption rules out adverse selection as well as hold-up problems (that may be induced by incomplete contracts). Brynjolfsson (1994), for instance, applied the incomplete contracts approach to study the impact of contractibility on the boundaries of firms. Nam et al. (1996) and Wang et al. (1997) studied these effects in the outsourcing relationship context.

As a consequence of assumptions 1, 3 and 5, the client's costs of the project with an externally developed fraction $\lambda$, have the distribution parameters $\mu_n(1-\lambda)$ and $\sigma_n^2(1-\lambda)^2$. The service provider's expected costs of the project have the distribution parameters $\mu_x\lambda$ and $\sigma_x^2\lambda^2$, respectively.

**Price Negotiation**

We use the individual preferences of the two parties to serve as a valuation criterion for the pricing. Therefore, the price is assessed on the basis of the risk adjusted costs of the client, on the one hand, and the risk adjusted costs of the service provider, on the other. As can be seen in Table 1, the risk adjusted costs of the client are made up of the internal risk adjusted development costs, the assessed price of the external fraction, and the transaction costs. In contrast, the risk adjusted costs of the service provider are made up of the external risk adjusted development costs, only. Consequently, for each project a price assessment according to the following scheme takes place.

The price $P(\lambda)$ for a certain externally developed fraction of a project ranges between an upper bound $U(\lambda)$, determined by the client's willingness to pay, and a lower bound $L(\lambda)$, determined by the service provider's minimum asking price. Between these limits, the two parties agree on an assessment outcome.

The client's willingness to pay for the externally developed fraction is determined by the *risk adjusted costs* the development of the *external* fraction $\lambda$ would cause *internally*. Therefore, the upper bound consists of the costs and risk of the supposed *additionally internally* developed fraction $\lambda$. Regarding the expected costs, this is straightforward. Regarding risk, the dependencies between the costs of the *already internally* developed fraction $(1-\lambda)$ and the *supposed additionally internally* developed fraction $\lambda$ has to be accounted for: With outsourcing, the client's risk is $\left(\sigma_n(1-\lambda)\right)^2$. Without outsourcing it is $\sigma_n{}^2$. Outsourcing therefore lowers the client's risk by ${\sigma_n}^2 - \left(\sigma_n(1-\lambda)\right)^2$. Finally, transaction costs have to be subtracted. This concludes in the following formula 1:

$$\begin{aligned} U(\lambda) &= \mu_n\,\lambda + \alpha_n\,\left({\sigma_n}^2 - \left(\sigma_n(1-\lambda)\right)^2\right) - \lambda f \\ &= \mu_n\lambda + \alpha_n{\sigma_n}^2(2\lambda - \lambda^2) - \lambda f \end{aligned} \tag{1}$$

For a single project, the client is willing to agree on every contract with a price below $U(\lambda)$, whereby a preferably low price is aspired. If the price exceeds $U(\lambda)$, the client would prefer to develop the entire project internally. If the price is equal to $U(\lambda)$, the client is indifferent between internal and external development. The price's lower bound is determined by the minimum price the service provider must achieve to obtain at least his risk adjusted costs, given the size of the fraction he is going to develop. The specific risk adjusted costs of the service provider are the following.

$$L(\lambda) = \mu_x\lambda + \alpha_x(\sigma_x\lambda)^2 \tag{2}$$

The service provider is willing to agree upon every contract with a price above $L(\lambda)$, whereby a preferably high price is aspired. If the price falls below $L(\lambda)$, the service provider is not willing to enter the commitment. If the price is equal to $L(\lambda)$, the service provider is indifferent whether to close the contract or not.

An agreement interval between client and service provider exists if $\exists\lambda \in [0;1]$: $U(\lambda) > L(\lambda)$. Keeping in mind that $U(0) = L(0) = 0$ and determining the first derivatives of $U(\lambda)$ and $L(\lambda)$ for $\lambda \to 0$, we find that this condition is true for $\mu_n + 2\alpha_n\sigma_n^2 > \mu_x + f$. As a first result we record that the existence of an agreement interval is independent from the service provider's risk aversion and project risk.

Nevertheless, for reasons of simplicity and to avoid case differentiations in the following, we require $\forall\lambda \in [0;1]$: $U(\lambda) \geq L(\lambda)$. This requirement is fulfilled for all $\lambda$ if $\mu_n + \alpha_n\sigma_n^2 \geq \mu_x + \alpha_x\sigma_x^2 + f$. Therefore, an agreement interval exists for all considered outsourcing degrees if (for the entire project) the risk adjusted costs of the client overweigh (or equal) the risk adjusted costs of the service provider plus the transaction costs. Since the market for specialized and competitive service providers is flourishing (Michell and Fitzgerald 1997), we suppose that this condition is given for most real world cases.

Figure 1 shows the upper and lower bounds and the resulting agreement interval (price range).

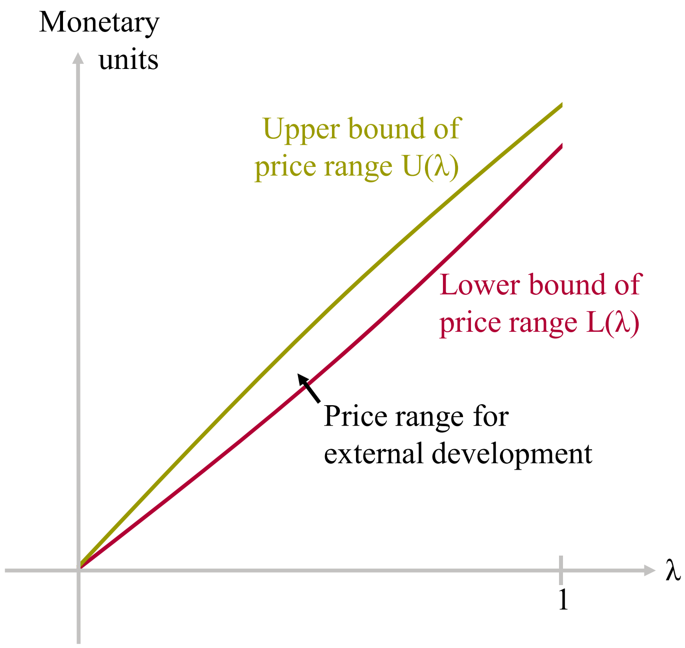


**Figure 1. Price Range for External Development**

Having established the agreement interval, we now turn to the question what price $P(\lambda)$ both parties should agree on. In order to do so, we interpret the price negotiation as a cooperative game and determine a "fair" partition of the agreement interval by applying game theoretic solution techniques. Both parties' payoff functions $u_n(\lambda)$, $u_x(\lambda)$ are given by the differences between $P(\lambda)$ and the respective risk adjusted costs. I.e., $u_n(\lambda) = U(\lambda) - P(\lambda)$ and $u_x(\lambda) = P(\lambda) - L(\lambda)$. It is easy to see that these payoff functions capture the gains from closing the contract. If, on the other hand, the two parties fail to reach a settlement, they only will receive their so-called disagreement payoffs $\underline{u} = (\underline{u}_n, \underline{u}_x)$. In the model presented here, failure of negotiations means that the project is developed completely internally and hence $\lambda = 0$. This obviously implies $u_n(0) = U(0) - P(0) = 0$ as well as $u_x(0) = P(0) - L(0) = 0$ and therefore $\underline{u} = (0{,}0)$.

If, on the other hand, client and service provider close the contract, the agreement interval $[L(\lambda), U(\lambda)]$ arises which we now strive to partition by setting $P(\lambda)$ adequately. One extreme case is an agreement where $P(\lambda) = L(\lambda)$ transfers the whole benefit to the client, yielding the allocation $(U(\lambda) - L(\lambda), 0)$. Contrarily, the allocation $\big(0,\ U(\lambda) - L(\lambda)\big)$ results when $P(\lambda) = U(\lambda)$ transfers the whole benefit to the service provider. Besides these extreme scenarios, any convex combination of these allocations can be achieved by setting a fixed price $P(\lambda) \in [L(\lambda), U(\lambda)]$. Please note that these convex combinations can be interpreted as expected payoff vectors when the players agree to jointly randomized strategies. Since negotiations might fail, the disagreement point $\underline{u} = \big(\underline{u}_n, \underline{u}_x\big)$ can also be reached with positive probability. Hence, all convex combinations of these three allocations are feasible outcomes. Let us term this convex polyhedron Δ the feasible set of the bargaining game.

We now strive to identify the allocation $(\hat{u}_n, \hat{u}_x) \in \Delta$ that should be selected as a result of negotiations. Similar to Nash (1950), we approach this problem axiomatically. I.e. we generate a list of properties that a reasonable bargaining solution ought to satisfy and use these properties to determine the bargaining solution. Since our axiom system differs somewhat from the one proposed by Nash (our solution, for instance, does not rely on an axiom of symmetry), we summarize briefly the solution technique used in this paper.

Our first axiom requires that neither player gets less in the bargaining solution than he would in the disagreement case:

**Axiom 1 (Individual Rationality) -** *$(\hat{u}_n, \hat{u}_x)$ is individually rational, i.e. $\hat{u}_n \geq \underline{u}_n$ and $\hat{u}_x \geq \underline{u}_x$.*

Since the bargaining game under consideration is a cooperative game, also collective (rather than individual) rationality considerations are relevant. We hence assert that a reasonable solution should be Pareto optimal:

**Axiom 2 (Efficiency) -** *$(\hat{u}_n, \hat{u}_x)$ is effcient, i.e. no $(u_n, u_x) \in \Delta$ exists with $(u_n, u_x) \neq (\hat{u}_n, \hat{u}_x)$, $u_n \geq \hat{u}_n$, and $u_x \geq \hat{u}_x$.*

Our last axiom is a direct consequence of assumptions 1 and 2. Since the preference functions used in our model are compatible to the Bernoulli principle, increasing affine utility transformations (that alter origin and unit of utility) represent the same preference orderings. Therefore, a sensible bargaining solution ought to be invariant to varying ways of measuring utility. I.e., the solution should change in the same way:

**Axiom 3 (Scale Invariance) -** *Let $(\hat{u}_n, \hat{u}_x)$ be the solution to a bargaining game with feasible set $\Delta$ and disagreement point $\underline{u}$. Now consider a rescaled bargaining game with feasible set $\Delta'$ and disagreement point $\underline{u}'$ where $\Delta \ni (u_n, u_x) \longmapsto (a_n + b_n u_n, a_x + b_x u_x) \in \Delta'$, $\underline{u} = \left(\underline{u}_n, \underline{u}_x\right) \longmapsto \left(a_n + b_n \underline{u}_n, a_x + b_x \underline{u}_x\right) = \underline{u}'$ , and $b_n, b_x > 0$. Then, the solution to the rescaled bargaining game is given by $(a_n + b_n \hat{u}_n, a_x + b_x \hat{u}_x)$.*

Axioms 1 through 3 are undisputed in cooperative game theory, cf. e.g. Nash (1950), Kalai and Smorodinski (1975), and Shapley (1953). Another common assertion ("independence of irrelevant alternatives") claims that eliminating feasible alternatives other than the disagreement point (that would not have been chosen) should not affect the solution. Because irrelevant alternatives do not exist in our model, we refrain from formulating an appropriate axiom.

As Kalai (1977) showed, every two-party bargaining game with a compact convex feasible set $\Delta$ and disagreement point $\underline{u} = \left(\underline{u}_n, \underline{u}_x\right)$ that satisfies axioms 1 through 3 as well as independence of irrelevant alternatives has an unique solution $(\hat{u}_n, \hat{u}_x) \in \Delta$. This solution is the point that maximizes $(\hat{u}_n - \underline{u}_n)^{1-\gamma}(\hat{u}_x - \underline{u}_x)^{\gamma}$ over all individually rational points in $\Delta$ and is called nonsymmetric Nash solution. Please note that the parameter $\gamma \in ]0,1[$ reflects the bargaining power of the parties: Here, higher values of $\gamma$ indicate more bargaining power of the service provider relatively to the client.

Now we apply the nonsymmetric Nash solution to determine the price $P(\lambda)$ for a certain externally developed fraction of the project. Since failure of negotiations implies $\lambda = 0$ and hence $\underline{u} = (0,0)$, the maximization problem to be solved simplifies as follows.

$$(\hat{u}_n - \underline{u}_n)^{1-\gamma}(\hat{u}_x - \underline{u}_x)^{\gamma} = \big(U(\lambda) - P(\lambda)\big)^{1-\gamma}\big(P(\lambda) - L(\lambda)\big)^{\gamma} \tag{3}$$

We now compute the nonsymmetric Nash solution by maximizing the right-hand side of equation (3) with respect to $P(\lambda)$. The first order condition is equivalent to

$$\gamma\big(U(\lambda) - P(\lambda)\big)^{1-\gamma}\big(P(\lambda) - L(\lambda)\big)^{\gamma-1} = (1-\gamma)\big(U(\lambda) - P(\lambda)\big)^{-\gamma}\big(P(\lambda) - L(\lambda)\big)^{\gamma}. \tag{4}$$

Agreements resulting in $P(\lambda) = L(\lambda)$ or $P(\lambda) = U(\lambda)$ are for the sole benefit of one party and thus not realistic. In addition to that, these solutions would involve case differentiations when solving equation (4) for $P(\lambda)$. Therefore, we only consider $L(\lambda) < P(\lambda) < U(\lambda)$. Straightforward algebra then yields

$$P(\lambda) = \gamma \cdot U(\lambda) + (1-\gamma) \cdot L(\lambda). \tag{5}$$

For reasons of space, we only remark that the second order condition is fulfilled, i.e. the second derivative of equation (3) with respect to $P(\lambda)$ is negative.

Please note that the price $P(\lambda)$ is a strictly increasing function of $\gamma$. Hence, $\gamma$ indeed quantifies the service provider's bargaining power. Substituting formulae (1) and (2) into equation (5), we finally arrive at the following explicit characterization of the price $P(\lambda)$ of each externally developed fraction.

$$P(\lambda) = \gamma(\mu_n\lambda + \alpha_n{\sigma_n}^2(2\lambda - \lambda^2) - \lambda f) + (1-\gamma)(\mu_x\lambda + \alpha_x(\sigma_x\lambda)^2) \tag{6}$$

**Derivation of the Objective Function**

The client's risk adjusted costs of development constitute the objective function which is to be minimized by choosing an optimal $\lambda$. It consists of the risky internal development costs, the risk-free transaction costs, and the assessed price. The transaction costs follow the term described in assumption 4. The pricing term follows equation (6). We regard these functions and all variables besides $\lambda$ as exogenously given and integrate them into the objective function. Thus, the costs of our project are represented by a normally distributed random variable with the expected value

$$\begin{aligned} M(\lambda) &= \mu_n(1-\lambda) + K(\lambda) + P(\lambda) \\ &= \mu_n(1-\lambda) + \lambda f + \gamma(\mu_n\lambda + \alpha_n{\sigma_n}^2(2\lambda - \lambda^2) - \lambda f) + (1-\gamma)(\mu_x\lambda + \alpha_x(\sigma_x\lambda)^2) \end{aligned} \tag{7}$$

and standard deviation

$$S(\lambda) = \sqrt{(\sigma_n(1-\lambda))^2} = \sigma_n(1-\lambda). \tag{8}$$

Therefore, using assumption 2, the project's risk adjusted costs are modeled according to the following structure.

$$\begin{aligned} \Phi(\lambda) &= M(\lambda) + \alpha_n\big(S(\lambda)\big)^2 \\ &= \mu_n(1-\lambda) + \lambda f + \gamma(\mu_n\lambda + \alpha_n{\sigma_n}^2(2\lambda - \lambda^2) - \lambda f) + (1-\gamma)(\mu_x\lambda + \alpha_x(\sigma_x\lambda)^2) \\ &\quad + \alpha_n(\sigma_n(1-\lambda))^2 \end{aligned} \tag{9}$$

After several algebraic transformations, equation (9) can be rewritten:

$$\begin{aligned} \Phi(\lambda) &= \mu_n + \alpha_n\sigma_n^2 - (1-\gamma)((\mu_n\lambda + \alpha_n{\sigma_n}^2(2\lambda - \lambda^2) - \lambda f) - (\mu_x\lambda + \alpha_x(\sigma_x\lambda)^2)) \\ &= \Phi_n - (1-\gamma)(U(\lambda) - L(\lambda)) \end{aligned} \tag{10}$$

As a result, equation (10) can be interpreted as follows: The risk-adjusted costs for a certain outsourcing degree $\Phi(\lambda)$ equal the client's risk-adjusted costs for the whole project $\Phi_n$ less the share $1-\gamma$ (reflecting the bargaining power) of the spread between $U(\lambda)$ and $L(\lambda)$, which in turn can be interpreted as the overall benefit from outsourcing.

## Optimization and Analysis

To obtain a first candidate $\hat{\lambda}$ for a minimal solution, we neglect that $\lambda \in [0,1]$. To fulfill the first order condition for optimality, we set the first derivative with respect to $\lambda$ equal to 0.

$$\frac{\partial \Phi(\lambda)}{\partial \lambda} = (1-\gamma)(f - \mu_n + \mu_x - 2\alpha_n\sigma_n^2(1-\lambda) + 2\alpha_x\sigma_x^2\lambda) \ = 0 \tag{11}$$

We solve the equation for $\lambda$ and get

$$\hat{\lambda} = \frac{\mu_n + 2\alpha_n\sigma_n^2 - (\mu_x + f)}{2\alpha_n\sigma_n^2 + 2\alpha_x\sigma_x^2}. \tag{12}$$

To fulfill the second order condition, the second derivative with respect to $\lambda$ has to be $> 0$.

$$\frac{\partial^2 \Phi(\lambda)}{\partial \lambda^2} = 2(1-\gamma)(\alpha_n\sigma_n^2 + \alpha_x\sigma_x^2) > 0 \tag{13}$$

With all exogenous parameters in the previously defined domains, the second order condition (13) is always true. Accounting for $\lambda \in [0,1]$, the parameter $\lambda^* = \hat{\lambda}$ constitutes an optimum, only if $\hat{\lambda} \in [0,1]$. Regarding equation (12), numerator and denominator are always positive, if an agreement interval exists (see section "price negotiation"). If $\hat{\lambda}$ takes values larger than 1, we choose the optimal solution $\lambda^* = 1$ for any $\hat{\lambda} > 1$ (cf. research question 1).

The client's expected costs $\mu_n$and risk $\sigma_n$ for the whole project, as well as the client's risk aversion $\alpha_n$ are positively linked to a higher outsourcing degree, transaction costs are negatively linked. Since $2\alpha_n\sigma_n^2$ is an additive term in numerator and denominator the outsourcing degree $\hat{\lambda} \in [0,1]$ increases for increasing risk aversion $\alpha_n$ or risk $\sigma_n^2$. Quite intuitively, a client will prefer to outsource more fractions of a project if his expected costs, risk, or risk aversion increase or if the transaction costs decrease.

The service provider's expected costs $\mu_x$ and risk $\sigma_x$ for the whole project, as well as the service provider's risk aversion $\alpha_x$ are negatively linked to $\hat{\lambda}$. This is comprehensible, too: the higher the service provider's expected costs, risk, and risk aversion, the lower the incentive to outsource.

Most interesting, the bargaining power $\gamma$ has no influence on the optimal outsourcing degree at all (cf. research question 2). This can be interpreted best considering equation (10): The client actually maximizes the overall benefit from outsourcing $U(\lambda) - L(\lambda)$. This is reasonable, as the client gets a fixed share $1 - \gamma$ (reflecting the bargaining power) of this benefit for any chosen $\lambda$. Obviously, the bargaining power $\gamma$ is irrelevant for the maximization of $U(\lambda) - L(\lambda)$ and therewith for the decision on the degree of outsourcing.

***Limitations***

Today, companies extend their focus from a pure cash-flow oriented view to a more generic one and integrate risk and dependencies into their decisions. Nevertheless, these approaches are often pragmatic and methodically weak. The vision of a value adding quantitative IT governance concerning risk and return requires methodically rigorous models that deliver initial reasonable results, although they might not be suitable to be applied in practice without adjustments. Therefore, a business-oriented model which is directly applicable but still methodically rigorous as well as an empirical analysis based upon real-world data will be the objective of future research. Thus, the limitations of this paper have to be addressed separately and analyzed profoundly.

First, the exclusion of risk for a fixed price outsourced fraction might not necessarily picture reality. We could also include the analysis of contract types other than fixed price. Furthermore, we currently neglect varying returns of projects and assume them to be constant regardless of the degree of outsourcing. Including e.g. comparative advantages of the service provider would provide a more eclectic picture of reality. Additionally, the linear relationship of the fraction's size to costs and risk, requested in assumption 3, might lead to a loss in generality, since different parts of a project might entail distinct values of costs and risks. Separate observation of different project parts with different risk/cost structures might be a practical addition.

Moreover, the inclusion of information asymmetries, e.g. with regard to the service's characteristics and quality, would provide insights into the incentive effects of outsourcing contracts. We expect that agency costs will then reduce the agreement interval. This topic indeed calls for further investigation and is therefore on our research agenda.

Concerning the bargaining model, we assume the two parties to be the only involved in the bargaining process and therefore omit the possibility of negotiating with other service providers. The effect of a fallback option for the client other than refraining from outsourcing still has to be examined.

***Conclusion and Outlook***

With this paper, we provide a model to determine the optimal degree for outsourcing a project at a fixed price. We find that within a fixed price outsourcing contract, the client strives to maximize the overall benefit from outsourcing. This does not depend on the client's bargaining power which is therefore irrelevant for the decision on the optimal degree of outsourcing. The major extension of this model and therewith the focus of our future research will be the investigation of bargaining power on outsourcing decisions in a portfolio context. If the outsourcing decision is to be taken on multiple projects, how will the bargaining power of either the client or the vendor(s) influence it?

Although this model pictures reality in a constrained way, it provides a basis for firms to plan and improve their outsourcing strategies. Thereby, it is not only of high relevance to business practice, but also provides a theoretically sound economical approach.

## *References*


Apte, U. M., Sobol, M. G., Hanaoka, S., Shimada, T., Saarinen, T., Salmela, T., and Vepsalainen, A. P. J. 1997. "IS Outsourcing Practices in the USA, Japan and Finland: A Comparative Study," *Journal of Information Technology* (12:4), pp. 289-304.

Aron, R., Clemons, E. K., and Reddi, S. 2005. "Just right outsourcing: Understanding and managing risk," *Journal of Management Information Systems* (22:2), pp. 37-55.

Arrow, K. J. 1971. "The Theory of Risk Aversion," in *Essays in the Theory of Risk-Bearing,* K. J. Arrow (ed.), Chicago: Markham, pp. 90-120.

Aspray, W., Mayadas, F., and Vardi, M. Y. 2006. "Globalization and Offshoring of Software. A Report of the ACM Job Migration Task Force," 2010-05-03 (available online at http://www.acm.org/globalizationreport/).

Aubert, B. A., Dussault, S., Patry, M., and Rivard, S. 1999. "Managing the Risk of IT Outsourcing," in *Proceedings of the 32nd Annual Hawaii International Conference on System Science*, Maui, Hawaii.

Aubert, B. A., Rivard, S., and Patry, M. 2004. "A transaction cost model of IT outsourcing," *Information & Management* (41:7), pp. 921-932.

Bernoulli, D. 1954. "Exposition of a New Theory on the Measurement of Risk," *Econometrica* (22:1), pp. 23-36.

Boehm, B., Abts, C., and Chulani, S. 2000. "Software development cost estimation approaches—A survey," *Annals of Software Engineering* (10:1), pp. 177-205.

Bryce, D. J., and Useem, M. 1998. "The Impact of Corporate Outsourcing on Company Value," *European Management Journal* (16:6), pp. 635-643.

Brynjolfsson, E. 1994. "Information assets, technology, and organization," *Management Science* (40:12), pp. 1645-1662.

Conrow, E. H., and Shishido, P. S. 1997. "Implementing risk management on software intensive projects," *IEEE Software* (14:3), pp. 83-89.

Currie, W. L. 2000. "Expanding IS Outsourcing Services through Application Service Providers," in *Proceedings of the Eighth European Conference on Information Systems (ECIS)*, Vienna, Austria.

Dewan, S., Shi, C., and Gurbaxani, V. 2007. "Investigating the Risk-Return Relationship of Information Technology Investment: Firm-Level Empirical Analysis," *Management Science* (53:12), pp. 1829-1842.

Dey, D., Fan, M., and Zhang, C. 2010. "Design and Analysis of Contracts for Software Outsourcing," *Information Systems Research* (21:1), pp. 93-114.

Dibbern, J., Goles, T., Hirschheim, R., and Jayatilaka, B. 2004. "Information Systems Outsourcing: A Survey and Analysis of the Literature," *ACM SIGMIS Database* (35:4), pp. 6-102.

DiRomualdo, A., and Gurbaxani, V. 1998. "Strategic intent for IT outsourcing," *Sloan Management Review* (39:4), pp. 67-80.

Dutta, A., and Roy, R. 2005. "Offshore Outsourcing: A Dynamic Causal Model of Counteracting Forces," *Journal of Management Information Systems* (22:2), pp. 15-35.

Freund, R. J. 1956. "The Introduction of Risk into a Programming Model," *Econometrica* (24:3), pp. 253-263.

Fridgen, G., and Müller, H. 2009. "Risk/Cost Valuation of Fixed Price IT Outsourcing in a Portfolio Context," in *Proceedings of the 30th International Conference on Information Systems (ICIS)*, Phoenix, Arizona.

Gopal, A., and Koka, B. R. 2010. "The Role of Contracts on Quality and Returns to Quality in Offshore Software Development Outsourcing," *Decision Sciences* (41:3), pp. 491-516.

Gopal, A., Sivaramakrishnan, K., Krishnan, M. S., and Mukhopadhyay, T. 2003. "Contracts in offshore software development: An empirical analysis," *Management Science* (49:12), pp. 1671-1683.

Han, K., Kauffman, R. J., and Nault, B. R. 2005. "Does IT outsourcing pay off? Evidence from industry-level data," in *Proceedings of the 10th Annual INFORMS Conference on Information Systems and Technology*, New Orleans/San Francisco.

Hanink, D. M. 1985. "A Mean-Variance Model of MNF Location Strategy," *Journal of International Business Studies* (16:1), pp. 165-170.

Kalai, E. 1977. "Nonsymmetric Nash solutions and replications of 2-person bargaining," *International Journal of Game Theory* (6:3), pp. 129-133.

Kalai, E., and Smorodinsky, M. 1975. "Other solutions to Nash's bargaining problem," *Econometrica* (43:3), pp. 513-518.

Lacity, M. C., and Hirschheim, R. A. 1993. *Information Systems Outsourcing: Myths, Metaphors, and Realities*, New York: John Wiley & Sons, Inc.

Lacity, M. C., and Willcocks, L. P. 1998. "An Empirical Investigation of Information Technology Sourcing Practices: Lessons from Experience," *MIS Quarterly* (22:3), pp. 363-408.

Lacity, M. C., Willcocks, L. P., and Feeny, D. F. 1996. "The value of selective IT sourcing," *Sloan Management Review* (37:Spring), pp. 13-25.

Lacity, M. C., and Willcocks, L. P. 2003. "IT Sourcing Reflections: Lessons for Customers and Suppliers," *Wirtschaftsinformatik* (45:2), pp. 115-125.

Lee, J. N., Huynh, M. Q., Kwok, R. C. W., and Pi, S. M. 2003. "IT Outsourcing Evolution: Past, Present, and Future," *Communications of the ACM* (46:5), pp. 84-89.

Loh, L., and Venkatraman, N. 1992. "Determinants of Information Technology Outsourcing: A Cross-Sectional Analysis," *Journal of Management Information Systems* (9:1), pp. 7-24.

Michell, V., and Fitzgerald, G. 1997. "The IT outsourcing market-place: vendors and their selection," *Journal of Information Technology* (12:3), pp. 223-237.

Nam, K., Rajagopalan, S., Rao, H. R., and Chaudhury, A. 1996. "A two-level investigation of information systems outsourcing," *Communications of the ACM* (39:7), pp. 36-44.

Nash Jr, J. F. 1950. "The bargaining problem," *Econometrica* (18:2), pp. 155-162.

Nault, B. R. 1997. "Quality differentiation and adoption costs: The case for interorganizational information system pricing," *Annals of Operations Research* (71:0), pp. 115-142.

Sauer, C., Gemino, A., and Reich, B. H. 2007. "The Impact of Size and Volatility on IT Project Performance," *Communications of the ACM* (50:11), pp. 79-84.

Shapley, L. S. 1953. "A Value for n-Person Games," in *Contributions to the Theory of Games II,* H. W. Kuhn and A. W. Tucker (eds.), pp. 307-317.

Slaughter, S., and Ang, S. 1996. "Employment outsourcing in information systems," *Communications of the ACM* (39:7), pp. 47-54.

Standish Group. 2009. "CHAOS Summary 2009," 2010-06-26 (available online at http://www.standishgroup.com/newsroom/chaos_2009.php).

Susarla, A., Subramanyam, R., and Karhade, P. 2010. "Contractual Provisions to Mitigate Holdup: Evidence from Information Technology Outsourcing," *Information Systems Research* (21:1), pp. 37-55.

Wang, E. T. G., Barron, T., and Seidmann, A. 1997. "Contracting structures for custom software development: The impacts of informational rents and uncertainty on internal development and outsourcing," *Management Science* (43:12), pp. 1726-1744.

Willcocks, L. P., Lacity, M. C., and Kern, T. 1999. "Risk mitigation in IT outsourcing strategy revisited: longitudinal case research at LISA," *Journal of Strategic Information Systems* (8:3), pp. 285-314.

Zimmermann, S., Katzmarzik, A., and Kundisch, D. 2008. "IT Sourcing Portfolio Management for IT Service Providers - A Risk/Cost Perspective," in *Proceedings of 29th International Conference on Information Systems (ICIS)*, Paris.