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IT Sourcing Portfolio Management for IT Services Providers - A Risk/Cost Perspective

Gestion du portefeuille d'externalisation des IT par les fournisseurs de services informatiques: une perspective centrée sur les risques et les coûts

Completed Research Paper

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Abstract

Utilizing a global IT sourcing strategy bears enormous growth potential. With the main focus on cost reduction in valuation of sourcing alternatives, risk and risk diversification effects are often inadequately considered or completely neglected. This systematically results in wrong decisions about global sourcing. Correct decisions are in particular important for the success of IT services providers (ITSP), which are the major beneficiaries of the market growth, though being faced with intensifying competition. This paper proposes a decision model for allocating software development projects of an ITSP to available sites in a risk/cost efficient way by adapting Markowitz's Modern Portfolio Theory to IT sourcing decision making. The suggested approach covers not only costs and sourcing risks but also interdependencies between both sites and projects. Additionally, we propose methods for quantifying the necessary input parameters. We demonstrate the practicability of our approach in a case study with data from a major ITSP.

Keywords: IT Sourcing Portfolio Management, Modern Portfolio Theory, Offshoring, IT Services Providers, Software Development Projects, Decision Model

Résumé

Cet article propose un modèle de décision pour allouer des projets de développement de logiciels d'un fournisseur de services informatiques pour des sites disponibles dans un but efficace de risque/coût, en transférant et en adaptant la Théorie du Portefeuille Moderne de Markowitz aux décisions d'implantation. L'approche suggérée couvre non seulement les coûts et les risques d'implantation, mais aussi les interdépendances entre les sites et les projets.

Introduction

Software development skills are now global commodities (Dutta and Roy 2005) and their degree of maturity in low-wage countries such as India has grown significantly in the past decade (Boston Consulting Group 2007). Developing software nearshore and offshore (in the sequel we use offshore for both terms) has become increasingly attractive due to the risen skills and low HR costs. As realizing this cost reduction potential is the key motivation for companies to pursue offshoring (Apte et al. 1997; Rottman and Lacity 2004), the offshore information technology (IT) services market is believed to grow further rapidly in the years to come (Aspray et al. 2006). Everest Research (2005) estimates the size of the offshore IT market to $23-24 bn in 2004 and to $50-53 bn in 2007 with further large growth potential. The beneficiaries of this market evolution will be primarily IT services providers (ITSP) since they take the ownership in the majority of offshoring deals (DiamondCluster 2005; Schaaf and Weber 2005). This is underscored by Everest Research (2005), who surveyed for the major offshore market India that 62% of the IT services offshoring market is fully owned by ITSP and another 15% fall due ITSP partly owned models. Just a rough quarter (23%) of the offshoring volume falls due inhouse offshoring of international companies.

Though, the market is still growing significantly, competition has strongly intensified for ITSP recently. This results from additional supply due to the rise of low-wage country ITSP such as Infosys or Wipro, who have multiplied their headcount and sales significantly in this decade (Nasscom 2008) and became important players. To reduce costs and maintain their competitiveness, the established ITSP such as IBM or Accenture built up large capacities in low-wage countries (Boston Consulting Group 2007). By the growing competition, successful completions of offshore projects and customer satisfaction have become more important in vendor selection and subsequently critical success factors for the ITSP branch. An alarming 38% of the offshored projects did not satisfy customers' needs (with even increasing tendency) whereas the same figure for onshore projects was just 19% (DiamondCluster 2005). An important reason for this situation are false sourcing decisions only based on HR cost differences which are a major driver for offshoring decisions (Lacity and Willcocks 1998; Ang and Straub 1998). But productivity differences, additional risks resulting from geographical, legal and cultural differences (Kliem 2004), and especially interdependencies between both sites and projects are often not considered adequately. One explanation for this may be the lack of suitable decision models since this issue has been neglected by literature so far (Dibbern et al. 2004).

The objective of this paper is to contribute to close this identified gap by developing a normative approach to support offshoring-decision making of ITSP. After discussing the applicability of Modern Portfolio Theory (MPT) of Markowitz (1952) to make sourcing decisions, we transfer MPT for allocating software development projects to different available sites in a risk/cost efficient way. Transferring MPT to evaluate both IT portfolios considering interdependencies between IT projects and site selection decisions considering interdependencies between sites is discussed already separately in IT portfolio management (ITPM) and location theory literature, respectively. But, for allocating software development projects on different sites, an integrated consideration of interdependencies between both sites and projects is required, as interdependencies between projects vary on the locations where the projects are conducted. Thus, we contribute primarily to sourcing theory by the integrated consideration of these interdependencies in an MPT-based decision model. Still, we do not stop at this point but also propose methods to quantify the necessary input parameters of the model like costs, risks as well as interdependencies between both sites and projects. In a case study using real world data of an ITSP, we illustrate the applicability of our approach. The results, amongst others, provide for evidence that considering interdependencies between both sites and projects may bear substantial cost saving potential from a portfolio point of view.

The paper is organized as follows. In Section 2 an overview on research in IT offshoring decisions is provided and a typical decision situation of an ITSP is illustrated by a case study. In Section 3 the model supporting site decisions is presented. Subsequently, in Section 4 the case study is continued applying the proposed model. The paper concludes in Section 5 with a discussion of the limitations and perspectives for further research.

Literature Overview

IT sourcing decisions comprise regional and organizational issues. IT outsourcing is defined by Hirschheim and Lacity (2000) as the "practice of transferring IT assets, projects, staff, and management responsibility for delivery of services from internal IT functions to third-party vendors". This definition covers the organizational dimension of IT sourcing. The regional dimension addresses the question of site selection from a geographical and cultural point of view. The location for operating IT assets and IT projects is the issue of concern here. The allocation of IT assets or

IT projects in low-wage countries is known as offshore sourcing (Carmel and Tjia 2005) or just offshoring (Gannon and Wilson 2007). Since a lot has already been written on the organizational dimension (Lacity and Hirschheim 1993; Barthelemy and Geyer 2001; Levina and Ross 2003), we focus on the regional dimension in the following. Moreover, due to differing decision situations and following the software lifecycle we focus on site decisions for IT projects rather than IT assets in this paper.

In literature numerous articles have been published on the drivers and criteria for site decisions (see e.g. Apte et al. 1997; Lacity and Willcocks 1998). Although a number of motives for relocating software development projects like the access to a larger pool of human capital, a better position in global markets or the concentration on core business activities are mentioned, the main motive is the cost reduction potential, necessitating a detailed analysis of the development costs. Hence, their correct estimation is crucial to allocate IT budgets efficiently and becomes more difficult with global distribution. To ensure a well-founded decision process, a disaggregation of costs in production and transaction costs is suggested (Dibbern et al. 2006).

Production costs depend on the loaded costs, which include HR costs, costs for benefits, space as well as overheads (Everest Research 2005), and the productivities at the different sites. Loaded costs, especially influenced by local HR costs, show substantial differences. For instance the US salaries are about eight times higher than the Indian salaries (Aspray et al. 2006). But those wage relations cannot be simply equated with the cost reduction potential that is realizable by relocation. This results from enormous differences in productivities at available sites in different countries (Cusumano et al. 2003). Hence, not considering lower productivities in low-wage countries often leads to an overestimation of the cost reduction potential of offshore development. Thus, the consideration of different productivities is essential to obtain a comparable value of the production costs.

Besides production costs that are relevant to the site decision, globally distributed work causes additional transaction costs, also labeled as extra offshore costs (Carmel and Tjia 2005), and may increase the production costs for an offshore development by more than half (Davidson 2003). Such transaction costs result from additional transaction effort, caused by sourcing and should therefore be also considered in sourcing decisions (Aubert et al. 2004; Poppo and Zenger 1998; Lammers 2004). For a more detailed examination, transaction costs may be differentiated into variable and fixed transaction costs. Variable transaction costs generally increase with the size of the project and include costs for traveling, management, communication and controlling (Dibbern et al. 2006). On the other hand, fixed transaction costs occur during the planning and set up of a software development project. They are (largely) independent of the project size. Typical kinds are legal, negotiation or initiation costs, such as costs for infrastructure set up and initial training costs for offshore staff.

Analyzing costs is not sufficient, though. Software development is a risky endeavor. According to the Chaos Report of the Standish Group (2004), only 29% of all projects were completed in time, in budget and as initially specified. This underscores the uncertainty associated with software development projects. Due to global sourcing, further risk influence factors such as cultural differences (Winkler et al. 2006), environment, communication, financial markets, technology, intellectual property and law (Apte et al. 1997; Kliem 2004) have to be considered additionally within the decision model. In literature, most articles deal with risks in a qualitative manner such as Gellrich and Gewald (2005), Aspray et al. (2006) or Aron et al. (2005). However, only few approaches try to quantify risks of IT sourcing such as Aubert et al. (1998), who identify undesirable outcomes that may result from an IT outsourcing deal from the point of view of an outsourcer. They use probabilities of undesirable outcomes and their expected losses to calculate a monetary risk exposure. While their framework to categorize risk factors is helpful in our case, first, we adopt the typical finance-oriented definition of risk as a negative as well as positive deviation from an expected value and, second, take the perspective of an ITSP.

ITSP generally carry out multiple projects at the same time. But unlike non-ITSP, ITSP do not have to take decisions on whether they want to outsource specific projects. Software development projects are mostly dependent on each other (McFarlan 1981). Such dependencies of projects can be structural or resource based.

- Structurally dependent projects are based on same processes, functions or data. If multiple software development projects are all based on one database, their successes are positively correlated, i.e. their successes develop as result of a change or incident at the database. For instance, if the quality of the data increases, all projects are influenced in a positive way. But if the database crashes, all projects are influenced negatively.

- Resource dependent projects compete for similar resources. If, for example, two projects need the same domain expertise, they will be positively correlated (assuming that available resources are not just allocated to either one

or the other of these projects). As long as the expertise can be made available, both projects will be a success otherwise both will fail.

To cover such interdependencies, a treatment of the whole IT landscape as a portfolio (Lacity and Willcocks 2003) is required, what is called ITPM. Already in the early 1980ies first approaches of ITPM came up (McFarlan 1981). In contrast to the isolated valuation of a single IT project (Bannister and Remenyi 2000), ITPM considers the contribution of an IT project to the complete portfolio of IT projects. Hence, ITPM marks an important opportunity for organizations to manage their IT more efficiently (Weill and Aral 2005). Oh et al. (2007) found out, that a higher level of ITPM maturity will significantly improve firm performance, which is also mentioned in a study of Jeffery and Leliveld (2004) exposing a high demand for and relevance of ITPM approaches in practice.

Quantitative ITPM methods and decision models were proposed e.g. by Verhoef (2002) and Moore et al. (2003), where conventional valuation approaches like Discounted Cash-Flow approaches are used for the assessment of IT portfolios without considering interdependencies between projects. Santhanam and Kyparisis (1996) and Butler et al. (1999) proposed ITPM methods using MPT, but they only modeled interdependencies among IT projects. However, for an adequate site allocation it must also be considered that interdependencies vary dependent on the site where the software development project is conducted.

A stream of literature coming from location theory deals with site decisions and interdependencies between sites – in particular where sites should be opened or included with regard to production and supply chain problems. We can broadly distinguish three basic quantitative approaches within this stream: Mixed-integer programming models (cf. Haug 1985; Timpe and Kallrath 2000), goal programming techniques (cf. Min and Melachrinoudis 1996; Hajidimitriou and Georgiou 2000) and mean-variance approaches such as Hanink (1985) or Hodder and Dincer (1986). The mentioned mean-variance approaches employ MPT and consider risks and interdependencies between sites to get an optimal site portfolio in a production setting.

Based on the necessity to combine project-specific as well as site-specific considerations and acknowledging the analogies of location theory and ITPM with regard to the application of mean-variance approaches, we transfer their underlying ideas to IT sourcing problems especially by modeling interdependencies between both sites and projects. This extension is required due to the facts that e.g. resource based dependencies between two projects can be totally different for each site because the differences in specialization and quantity of HR and moreover site specific dependencies, which influence the risk/cost position of an IT portfolio, may additionally emerge. Two sites at one country or region are in general positively correlated because of economic effects or political crises which are influencing more sites in a specific region in the same way. Globally distributed sites do not underlie the same effects as sites within one region. So conducting projects at sites lying in different regions may help to reduce the overall risk an ITSP has to bear – we may also call this its portfolio risk – because the sites are less positively correlated.

Such a risk/cost integrating model to support sourcing decisions of global operating ITSP under consideration of interdependencies between both sites and projects – denoted as a method for IT Sourcing Portfolio Management – is introduced in the following section. Before turning to the model the following case study shall illustrate a typical decision situation of an ITSP. As the case study is based on real business cases of an ITSP, the names and all possible identifying details are disguised for reasons of confidentiality.

ACME is a worldwide operating ITSP and is running software development projects for its clients at its globally distributed software delivery centers.

The German branch of ACME has a specialized division for clients in the financial sector and recently acquired three long-term projects to develop software for three globally relevant financial services providers. All projects are designed to run over a three year horizon with constant division of work over the runtime:

- Project 1: A-Bank plans to introduce a brokerage and financial asset administration system to provide for a better and faster service to its customers and a better administration of the customer data for the employees. The challenge is to integrate the functionalities for customers and the back office. The mission of ACME is to implement a new system using J2EE technology and migrate the highly sensible customer data. Due to the tasks the system should perform the implementation effort is estimated to 600,000 lines of code (about 200,000 lines of code per year).

- Project 2: B-Bank changed its IT strategy with the objective to replace the old application based architecture by a modern, more flexible Service-Oriented Architecture. B-Bank expects better data integration, faster

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communication and a stronger linkage between its different divisions from the IT reorganization. The first step is the implementation of a company-wide system for business intelligence. ACME's challenge is to implement a single enterprise architecture across all divisions facing the challenge of a complex technological solution and the need for a great reuse of the software. The experts estimate the effort to 240,000 lines of code (about 80,000 lines of code per year).

- Project 3: C-Bank pursues a similar strategy compared to B-Bank. Due to another organization of the company and a more complex integration of the current databases accompanied by a more laborious migration the effort is estimated to 360,000 lines of code (about 120,000 lines of code per year).

ACME has negotiated contractually fixed prices for the three projects and has now to decide how to allocate the projects on its sites. Since the responsible executives already have experiences in nearshore/offshore sourcing they take into account their German site and two delivery centers they already cooperated with in former projects for their decision:

- Site 1 – Germany: ACME usually implements the software development projects for its German clients at its site in Frankfurt/Main. Thus, no additional sourcing/offshore costs arise in this case. Germany has a labor pool with matured IT specialists and a low fluctuation, but comparably high labor costs because of the German wage levels. Another main advantage of developing onshore for a German client is the fact that all parties involved speak German because any relocation would necessitate the (co-)usage of English as project language and as a primary language in the documentation.

- Site 2 – Czech Republic: ACME runs a delivery center in Prague. This nearshore site has become a very popular sourcing location for German clients as the skills of the employees are nearly as mature as in the German branch, both cultures are similar and many of the employees speak or have at least basic knowledge of German what fosters the communication. The fully loaded costs are about half as high as in Germany but with a higher expected annual increase. Sourcing work to this nearshore site causes moderate transaction costs.

- Site 3 – India: ACME also operates a large delivery center in Bangalore. The skills of the Indian IT specialists are nowadays comparable to that of German or American specialists. A disadvantage for India lies in the cultural differences to Europe and the limited German abilities. The labor costs are significantly lower than in the other regarded countries, but with the greatest rate of increase.

After indentifying the potential locations the executives of the German division had to decide on the allocation of the projects to the available sites in a risk/cost efficient way. Therefore they estimated the onshore effort in person months using the established estimation model COCOMO (Boehm et al. 2000) for the three projects. Subsequently, they multiplied the estimated effort with the average loaded costs for an employee per month of each site to get the development costs for each project at each possible site. The risks are considered by a premium on the development costs based on qualitative ratings and historical data depending on the site where the project is conducted. Another site-specific surcharge was made for upcoming fixed costs at the different sites which are based on information about setting up previous projects at the three sites. Based on these information, taking into account that the projects can be modularized to a certain extend and after a consultancy of their colleagues from the delivery centers they made the distribution decisions for each project independently and decided to conduct the projects as shown in Table 1.

Table 1. Original site distribution of ACME			
	Project 1	Project 2	Project 3
Site 1 – Germany	80%	75%	67%
Site 2 – Czech Republic	20%	0%	0%
Site 3 – India	0%	25%	33%

As this approach led in a couple of times to unsatisfied results in the past and as ACME is faced with intensified competition due to the rise of several competitors from low-wage countries, the executives of the German division of ACME were wondering, whether they could have done better in this decision process. They had the feeling that with a more sophisticated approach to estimate the site-specific costs as well as to consider risks and interdependencies they might have been able to realize cost reduction potential for their division.

Model

For more than 50 years it is common understanding in financial theory as well as in business practice that building a portfolio of multiple risky financial assets is in most cases by far superior in comparison to just investing in one single risky asset – even if this one promises the highest expected return (Markowitz 1952). While the expected return of a portfolio of risky financial assets is the sum of the weighted expected returns of the single assets, such an aggregation for the associated risk is not correct. It can be easily shown that – depending on the pair wise correlation and the weights of the individual assets in the portfolio – the overall risk of the portfolio might even be less than the lowest risk of all individual assets separately, since the risks of different financial assets generally not materialize all at the same time. This effect is called "risk diversification" and is widely utilized in the financial world. A positive correlation of two assets might stem from a similar exposure to an economic up- or downturn, while a negative correlation might stem from the fact that two different industries – and thus companies – are affected reversely from an innovation in the market. If the returns of the financial assets in the market are not perfectly positively correlated – which is by and large the case – risk can be diversified and investors can benefit by not "putting all their eggs in just one basket".

The basic idea of risk diversification in a portfolio context has already been transferred to other domains such as product portfolios (Cardozo and Smith 1983), customer portfolios (Kundisch et al. 2008; Buhl and Heinrich 2008) and site portfolios (Hanink 1985; Hodder and Dincer 1986). The domain of IT project portfolios also seems to have some characteristics that are compatible with the basic problem properties in financial decision making. Thus, Modern Portfolio Theory (MPT) of Markowitz has also been proposed to be applied to IT project portfolios (Santhanam and Kyparisis 1996; Butler et al. 1999; Asundi and Kazman 2001). However, Asundi and Kazman (2001) also observed problems transferring MPT to IT decision making. Financial assets are – in opposite to IT assets – characterized by steady marketability (Kersten and Verhoef 2003), i.e. investments and liquidations are possible (nearly) all the time. The liquidity of the considered assets is a necessary assumption for applying MPT. Therefore, Verhoef (2002) states that MPT is not adequate to support IT decision making because IT investments become illiquid by their conversion into software functionality. Verhoef's critique is appropriate, but does not comprise the problem of allocating software development projects to different available sites in a risk/cost efficient way like examined in this paper where the objects of investigation are software development projects before converting them into software. At this point in time – before the investment – the projects are still liquid assets where each possible site/project combination is characterized by its particular risk and return.

MPT assumes also a frictionless market, i.e. neither transaction costs nor taxes exist (Markowitz 1952). But in reality, offshoring causes transaction costs as already mentioned. Since transaction costs also arise on financial markets, MPT was accordingly further developed to include variable transaction costs (Pogue 1970) and fixed transaction costs (Patel and Subrahmanyam 1982). Drawing from these extensions of MPT, we will also include variable and fixed transaction costs in our model. Still, taxes can be mathematically treated like transaction costs (Pogue 1970) and thus be considered in the model. Moreover, the assets included in a standard MPT optimization process have to be infinitely divisible. Though this is apparently not true for financial assets – you can hardly buy half a share – this is even less true for software development projects, since they cannot be cut arbitrarily in parts. Nevertheless, for the time being we assume that projects can be cut in such a manner. Though projects may not be cut arbitrarily in the real world, they usually consist of different modules such as functional blocks and may be cut along them. However, such cuts often will not be completely consistent with the optimal solution but at least coming close. Cardozo and Smith (1983) found the same and made a similar assumption in the context of optimizing product portfolios with MPT.

To clarify our model, first its notations and assumptions are introduced. Subsequently, we illustrate how to allocate software development projects to the available sites in a risk/cost efficient way using MPT considering transaction costs.

Notations and Assumptions

An ITSP has to conduct *M* software development projects simultaneously for his clients and receives for each project (denoted by *m*) a contractually fixed income. Each project runs over multiple periods, whereas LOC_m denotes the amount of software that has to be produced for each project and per period in lines of code. The production of one line of code comprises not only its implementation but also its definition, design and test. To conduct the projects, the ITSP has *N* available sites underlying no capacity constraints. At each site (denoted by *n*) exists

different experiences, know-how and specialization in certain kinds of software development projects. This results in different productivities and in combination with the site specific loaded costs in different production costs for each possible site/project combination (SPC). The development costs per line of code (LOC-costs) are resulting from the production costs and additional variable transaction costs. Since unpredictable effects may occur during the planning horizon of the projects, the LOC-costs for each SPC cannot be determined deterministically. To consider uncertainty the following assumption is necessary.

> **Assumption 1:** *The LOC-costs are uncertain net present values, which are represented by a normally distributed ($N(\mu,\sigma)$) random variable $\tilde{C}_{n,m}$. Risk is understood as possible negative or positive deviation from the given expected value $E(\tilde{C}_{n,m}) = \mu_{n,m}$ and is quantified by the given standard deviation $\sigma(\tilde{C}_{n,m}) = \sigma_{n,m}$.*

Note that the optimization results would not change, if we considered just the downside risk of $\mu_{n,m}$ using the semi-standard deviation since we assume a symmetric distribution here. We follow standard MPT and use the standard deviation.

Projects may not only be conducted on single sites, rather some projects are designed as multi-site projects, by sourcing certain activities to specialized sites. Some sites may be specialized in programming interfaces, others in programming functionality. To model this and to get a risk/cost efficient project/site portfolio, we have to generate portfolio shares $w_{n,m}$ representing the percentage rate of the project work to be done at one SPC. This implies that all projects are infinitely divisible and distributable to the different sites. The portfolio shares $w_{n,m}$ are the decision variables for the optimization over the planning horizon and represent shares of the effort for all projects. The optimization is subject to the following constraints:

$$1) \quad w_{n,m} \geqq 0 \quad \wedge \quad \sum_{n=1}^{N} w_{n,m} = \frac{LOC_m}{\sum_{m=1}^{M} LOC_m}$$

Besides variable transaction costs which are a premium on the production costs (Pogue 1970) and are therefore included in the LOC-costs for each SPC, sourcing also causes fixed transaction costs $C^f_{n,m}$. They occur if and only if an SPC becomes part of the portfolio, i.e. if a project is at least partially conducted on a site, and have to be considered in calculating the expected LOC-costs of the portfolio $E(\tilde{C}_{PF}) = \mu_{PF}$.

To cover the project- and site-specific interdependencies as described in the literature review, they have to be considered in calculating the portfolio risk $\sigma(\tilde{C}_{PF}) = \sigma_{PF}$. Stochastic dependencies can be represented by a correlation coefficient ρ_{gh}, where both g and h are representing one SPC (n,m-combination) each.

Now we may calculate the efficient frontier of risk/cost efficient site/project portfolios. The efficient frontier represents the set of efficient SPC-portfolios. A SPC-portfolio is denoted as being efficient if given an expected return, no other SPC-portfolio can be found with a lower standard deviation or given a standard deviation, no other SPC-portfolio can be found with a greater expected return. All SPC-portfolios that do not lie on the efficient frontier are dominated and thus represent an inefficient and suboptimal allocation. But it is not obvious which portfolio should be selected by a risk averse decision maker. To calculate an optimal portfolio we need a preference function integrating risks and costs of a portfolio. Therefore a further assumption is necessary.

> **Assumption 2:** *It exists a utility-function $u(\tilde{C}_{PF})$ which assigns a specific utility to every random variable $\tilde{C}_{PF}$ and which is compatible with the Bernoulli-principle. We assume a risk averse decision maker that maximizes utility by taking into account uncertain costs.*

Applying the preference function we will call the result risk adjusted costs Φ_{PF} in the following. Table 2 summarizes the parameters of the model.

Table 2. Parameters of the model		
Symbol	Definition	Parameterization in the case study (see next section)
LOC_m	Amount of software that has to be produced for each project m and per period in lines of code	Given as input data by ACME
$E(\tilde{C}_{n,m}) = \mu_{n,m}$	Expected costs per line of code per combination of site n and project m (site-project-combination SPC)	Determined with the cost estimation model COCOMO and with the introduced method based on risk scenarios
$\sigma(\tilde{C}_{n,m}) = \sigma_{n,m}$	Risk per SPC	Determined with the introduced method based on risk scenarios
$C_{n,m}^f$	Fixed costs per SPC	Given as input data by ACME (based on historical data)
ρ_{gh}	Correlation coefficient capturing the linear correlation between two SPC (or n,m-combinations, respectively)	Determined with the introduced method
$w_{n,m}$	Portfolio weights – Decision variables of the optimization	Resulting shares per SPC as optimization result of the described approaches in the case study
$E(\tilde{C}_{PF}) = \mu_{PF}$	Expected costs per line of code of the portfolio	Calculated with the introduced model
$\sigma(\tilde{C}_{PF}) = \sigma_{PF}$	Portfolio risk	Calculated with the introduced model
Φ_{PF}	Risk adjusted costs of the portfolio	Calculated as result of the preference function
a	Risk aversion of the decision maker (see next subsection)	Estimated based on risk surcharges of ACME

Portfolio Optimization

To get an optimal portfolio, we first have to set up an equation to calculate the expected LOC-costs per line of code of a SPC-portfolio. Therefore we sum up the expected LOC-costs per line of code of each SPC weighted with the adherent portfolio shares and the arising fixed costs normalized to one line of code. To consider the fixed costs, which come up when a SPC is part of the portfolio and independent of the amount of strictly positive portfolio shares, we use the signum function (Courant and John 1965), which returns either 0 if $w_{n,m} = 0$ or 1 if $w_{n,m} > 0$.

$$2) \quad E(\tilde{C}_{PF}) = \sum_{n=1}^{N}\sum_{m=1}^{M} w_{n,m} \cdot \mu_{n,m} + \frac{\mathrm{sgn}(w_{n,m}) \cdot C_{n,m}^f}{\sum_{m=1}^{M} LOC_m} = \mu_{PF}$$

Following MPT, the portfolio risk is calculated based on the individual project risks, the pairwise correlations between all SPC and the weights of the single SPC using the auxiliary variables g and h representing a SPC (n,m-combination) each as follows:

$$3) \quad \sigma(\tilde{C}_{PF}) = \sqrt{\sum_{n_g=1}^{N}\sum_{m_g=1}^{M}\sum_{n_h=1}^{N}\sum_{m_h=1}^{M} w_{n_g,m_g}\sigma_{n_g,m_g} w_{n_h,m_h}\sigma_{n_h,m_h}\rho_{(n_g,m_g),(n_h,m_h)}} = \sqrt{\sum_{g=1}^{N\cdot M}\sum_{h=1}^{N\cdot M} w_g\sigma_g w_h\sigma_h\rho_{gh}} = \sigma_{PF} \;\; ; -1 \leqq \rho_{gh} \leqq 1$$

We choose a preference function that integrates costs and risk in a classical μ-σ-rule and that is compatible – under the constraints of normally distributed random variables (Assumption 1) and a risk averse decision maker – with the Bernoulli-principle (Assumption 2) at the same time. Such a preference function is given by the following equation (Schneeweiss 1967; Freund 1956), which has already been applied in a similar context (Hanink 1985):

$$4) \quad \Phi_{PF}(\mu_{PF}, \sigma_{PF}) = -\mu_{PF} - \frac{a}{2}\sigma_{PF}^2 \rightarrow \max!$$

The expected portfolio LOC-costs enter negatively into the preference function to get an objective function to be maximized. The Arrow-Pratt parameter a represents the individual level of risk aversion (Arrow 1970) which is expressed by a positive value.

The objective function is based on the preference function 4) and is composed of two parts, the expected portfolio LOC-costs per line of code from 2) and the portfolio variance representing the portfolio risk from 3). Since LOC-costs refer to a single line of code, both the expected portfolio LOC-costs and the portfolio variance have to be multiplied with the sum of LOC_m to calculate the risk adjusted costs of the whole sourcing portfolio.

$$5)\max\ \Phi_{PF} = (-(\sum_{n=1}^{N}\sum_{m=1}^{M}w_{n,m}\cdot\mu_{n,m} + \frac{\mathrm{sgn}(w_{n,m})\cdot C_{n,m}^{f}}{\sum_{m=1}^{M}LOC_{m}}) - \frac{a}{2}\cdot\sum_{g=1}^{N\cdot M}\sum_{h=1}^{N\cdot M}\sigma_{g}\cdot\sigma_{h}\cdot w_{g}\cdot w_{h}\cdot\rho_{gh})\cdot\sum_{m=1}^{M}LOC_{m}$$

$$\text{s.t.:}\ w_{n,m}\geqq 0\ \ \wedge\ \ \sum_{n=1}^{N}w_{n,m} = \frac{LOC_{m}}{\sum_{m=1}^{M}LOC_{m}}$$

As the behavior of the fixed costs was modeled with the signum function, the objective function has jump discontinuities (Courant and John 1965) and cannot be solved analytically. Because of this, a time consuming calculation is necessary, namely ($2^{n\cdot m}$-1) different optimizations and subsequent additions of the fixed costs. To reduce computing time, a heuristic may be applied like the subtract-add-approach described e.g. in Buhl and Heinrich (2008).

Operationalization: case study with a major ITSP

Economically sound IT Sourcing Portfolio Management has not made its way so far into business practice. As we found based on numerous discussions with executives of several ITSP, sourcing decisions are mostly made with the focus on single projects and usually the main decision criterion is the HR cost difference. If risks are considered at all, they are added by a premium on the expected costs based on qualitative ratings like described in the introduced case study of ACME. In general dependencies between projects and sites are not considered. To mitigate this shortcoming, we now illustrate how the model presented in the previous section may be operationalized (for the sake of simplicity without considering running projects as well as already known future project assignments) by continuing the case study of ACME facing the following major challenges:

1. How can the expected LOC-costs, the risks, and the fixed transaction costs of a site concerning a project be estimated with a higher precision?

2. How may the interdependencies between the possible combinations of sites and projects be parameterized using correlations?

3. How may the model be applied to demonstrate the advantages of considering interdependencies?

To estimate the costs of software development projects, ACME uses the cost estimation model COCOMO. However, using COCOMO, ACME does not cover productivity differences at the different sites because they only valuate the effort of projects onshore and multiply this estimation with site-specific labor costs. To cover such productivity differences of the different sites the estimation has to be done for each project at each site. Furthermore, COCOMO was first and foremost developed to estimate the production costs. To consider variable transaction costs caused by sourcing we had to enhance COCOMO additionally. By a transformation of the COCOMO equation we got the labor productivity as ratio of output (measured in lines of code) over input (measured in person months), which is the basis for the production costs. Variable transaction costs result from additional sourcing effort, which is not included in the calculated labor productivity. Thus, we have enhanced COCOMO by multiplying the labor productivity with a sourcing factor which is normalized between 0 and 1. By growing transaction effort the sourcing factor becomes smaller and decreases the labor productivity. Based on the resulting total productivity in combination with the loaded costs, we were able to calculate the net present value of the development costs per line of code deterministically for each SPC ($DC_{n,m}$) using the risk-free rate. The detailed enhancement of the COCOMO model to estimate the $DC_{n,m}$ including production and variable transaction costs is described in Katzmarzik et al. (2008). To calculate the development costs for the nine possible SPC applying this COCOMO enhancement we had to identify the input parameters to calculate the labor productivities, the sourcing factors and the loaded costs for each SPC. To calculate the labor productivities, we needed the effort multipliers, the scale factors and the calibration constants of the original COCOMO model which have already been estimated by ACME for the three projects onshore to apply COCOMO for their conventional cost estimation. To get these input parameters for all the other sites, the executives of ACME assigned their colleagues at the delivery centers in the Czech Republic and India to determine the input parameters like ACME did in Germany. The site specific sourcing multipliers (input parameters of the sourcing factor) representing additional management effort, communication effort and traveling effort were estimated based on historical data and experience values of conducting projects at the three considered sites and

were checked by executives of ACME. To determine the average HR costs we calculated the HR costs per person as arithmetic mean of the team structure which is globally unitary and composed of a manager, two experienced team leaders and six software engineers. The loaded costs are calculated of the average HR costs and additional costs for benefits, space and overheads (also deduced from historical data of ACME). Furthermore, loaded costs are assumed to grow in Germany by 2%, in the Czech Republic by 5% and in India by 10% per year (or period). With all these information and the enhanced COCOMO approach of Katzmarzik et al. (2008) we were able to calculate the $DC_{n,m}$.

To get the LOC-costs $\tilde{C}_{n,m}$ as a random variable and the corresponding moments $\mu_{n,m}$ and $\sigma_{n,m}$, we estimated the risks for each SPC. Therefore, we defined based on the idea of Aubert et al. (1998) independent scenarios for each SPC by identifying project and site specific risk influence factors. For each scenario we estimated the expected change of $DC_{n,m}$ ($\Delta DC_{n,m}$) and the (subjective) probability of occurrence (instead of the qualitative ratings chosen by ACME formerly to define its risk premium).

Based on this information we calculated $\mu_{n,m}$ and $\sigma_{n,m}$ for each SPC. The following example illustrates the estimation of the expected LOC-costs and the risk for Project 1 ("Introducing a brokerage and financial asset administration system") conducted at Site 3 ("India"). Based on a risk-free-rate of 5%, monthly average loaded costs per team member of $2,900 and an average productivity of the team (including the project management) of 195.8 lines of code per person month (including definition, design, implementation and test), the net present value $DC_{IND,1}$ as periodical ratio of the average loaded costs over the productivity were calculated to $46.58. Table 3 summarizes the selected risk scenarios with their probabilities of occurrence (estimated by executives of ACME) and the $\Delta DC_{IND,1}$.

#	description of the scenario	$p_{IND,1}$	$\Delta DC_{IND,1}$
	Table 3. Risk scenarios (Extract)		
1	The software shall be developed on a new platform. This was classified as a technology risk which occurs if the development does not work like planned on the new platform.	20%	+ $8.00
2	The IT infrastructure in Bangalore was not running stable in the last months. Further breakdowns during the runtime of the project leads to a decreasing productivity.	30%	+ $10.00
3	Two new specialized managers are actually searched on the very tight labor market in India for the site in Bangalore. If they can be hired the productivity increases.	20%	- $8.00
4	To conduct the project an intensive collaboration of 3 brokerage specialists is required. Their availability is not secured. Therefore external specialists may have to be acquired.	40%	+ $10.00

The scenarios, the probabilities and the resulting development costs are represented in the decision tree in Figure 1.

Figure 1. Decision tree for LOC-costs for *n*=IND and *m*=1
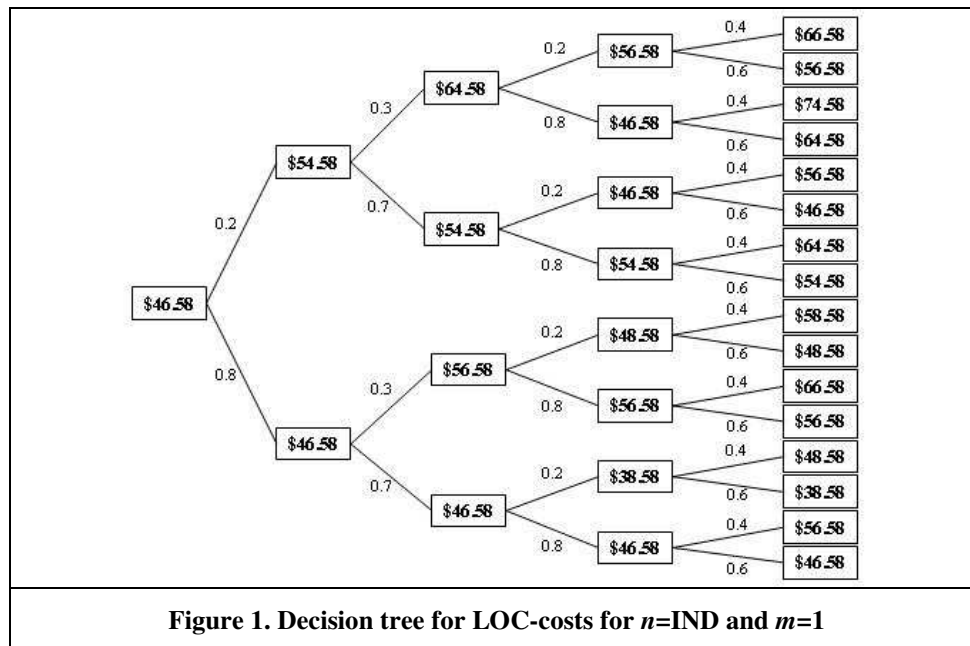
Based on the resulting instances of the development costs per line of code (values of the end nodes) and the according conditional probabilities we were able to calculate the expected LOC-costs for Project 1 being carried out in India to $\mu_{IND,1}$ = \$53.58 and the respective standard deviation to $\sigma_{IND,1}$ = \$8.09. The calculated values were then used as approximations for the two moments of the normal distributed random variable of the LOC-costs $\tilde{C}_{IND,1}$.

The fixed transaction costs for each SPC could be simply taken from the business cases. They consist of negotiation, planning and traveling costs for the setup of the project. Thus, the greater cultural and geographical distance is the reason for the higher fixed costs for the Indian in comparison to the Czech site.

With this procedure we estimated all expected LOC-costs and their standard deviations per line of code as well as the absolute fixed costs as listed in Table 4.

Table 4. Input parameters									
	n=GER m=1	n=CZ m=1	n=IND m=1	n=GER m=2	n=CZ m=2	n=IND m=2	n=GER m=3	n=CZ m=3	n=IND m=3
$\mu_{n,m}$[\$]	88.50	116.72	117.24	70.95	93.57	93.99	53.58	70.66	70.98
$\sigma_{n,m}$ [\$]	4.43	5.84	5.86	6.39	8.42	8.46	8.09	10.56	10.65
$C^f_{n,m}$ [\$]	0	0	0	110,000	100,000	100,000	160,000	200,000	200,000

The correlation coefficients were also determined together with experts of ACME. The starting point was the experience of the experts that projects that are performed on different sites do not seem to have a direct correlation. This is partly due to the fact that resources are not globally shifted between different sites in the short run. However, there are site dependencies based on political risks, cultural differences and other factors already discussed above that have to be taken into account. Thus, for all projects that are performed on different sites, just the site correlations are relevant. (This was also assumed for projects that are designed as multi-site projects.) We estimated this by using the correlations of region specific stock market indices as proxies because the risk factors mentioned above are (roughly) priced into these indices. Namely, we used the CECE Composite Index as a proxy for the Czech Republic site, the German blue-chip index DAX for the German site and the MSCI-India for the Indian site. Based on the discrete daily returns for one year, we arrived at the following correlations (see Table 5):

Table 5. Site Correlation			
	Germany	Czech Republic	India
Germany	1	0.69	0.64
Czech Republic	0.69	1	0.59
India	0.64	0.59	1

The figures were consistent with our expectations that the correlation between the neighboring countries Germany and Czech Republic is higher compared to the correlation between the European countries and India. Moreover, due to the higher economical integration we expected a higher correlation between Germany and India compared to the Czech Republic and India, which is also consistent with our results.

The next step was to get a hand on the correlation of projects that are performed on the same site. In our case, there were specifically resource conflicts that could be expected rather than having high structural dependencies. Still, these dependencies differed among the three projects. Since it is very hard to come up with exact estimations for the correlations of different projects, we defined instead four classes of dependencies based on three different kinds of dependencies resulting from conflicts that could occur if projects compete on human resources:

- industry/functional knowledge
- technical knowledge
- knowledge of client specific processes and problems.

Table 6. Project dependency classes based on potential resource conflicts				
Class	High dependencies	Mediocre dependencies	Low dependencies	No dependencies
Number of conflicts	3	2	1	0
Used correlation	1	0.67	0.33	0

As can be seen in Table 6 there are no negative correlations. This could happen if a specific project gets all the available resources and it performs very well, while other projects that compete on the same resources would suffer accordingly. However, the correlation estimations above were based on the assumption that given two projects compete for the same resources, such as a specific technical expertise, the available resources are evenly distributed among the projects. Franke and Hax (2004) also suggest that investments in real assets are usually positively correlated.

In our case all projects needed the same industry/functional knowledge and on top the projects 2 and 3 both required the same technical knowledge. With these considerations and several validation checks with business case experts of ACME, we ended up with the following correlations for all SPC as shown in Table 7.

	n=GER m=1	n=CZ m=1	n=IND m=1	n=GER m=2	n=CZ m=2	n=IND m=2	n=GER m=3	n=CZ m=3	n=IND m=3
n=GER, m=1	1	0.69	0.64	0.33	0.33	0.33	0.33	0.33	0.33
n=CZ ,m=1	0.69	1	0.59	0.33	0.33	0.33	0.33	0.33	0.33
n=IND, m=1	0.64	0.59	1	0.33	0.33	0.33	0.33	0.33	0.33
n=GER, m=2	0.33	0.33	0.33	1	0.69	0.64	0.67	0.67	0.67
n=CZ ,m=2	0.33	0.33	0.33	0.69	1	0.59	0.67	0.67	0.67
n=IND, m=2	0.33	0.33	0.33	0.64	0.59	1	0.67	0.67	0.67
n=GER, m=3	0.33	0.33	0.33	0.67	0.67	0.67	1	0.69	0.64
n=CZ ,m=3	0.33	0.33	0.33	0.67	0.67	0.67	0.69	1	0.59
n=IND, m=3	0.33	0.33	0.33	0.67	0.67	0.67	0.64	0.59	1

Table 7. Correlation coefficients between the SPC

Besides the estimations for the expected LOC-costs, risks and correlation coefficients for each SPC, the estimation of the risk aversion parameter is a major challenge. For this we compared the risk surcharges ACME chose in its former approach with the estimated variances of our approach. We found out that the values are linearly dependent of each other what implicates that a constant risk aversion parameter a with the value of 2.0 is reasonable.

To examine the enhancements of considering interdependencies we apply our model in two ways. Today ITSP meet their sourcing decisions in general isolated for each project. To clarify the enhancement of our model for this case we calculate an optimal allocation over all sites for each project isolated from the others. Further on, this is called the "isolated approach". Then, we optimize the site distribution in a holistic way as a portfolio in additional consideration of interdependencies between the projects. In the following, this is called the "integrated approach". To exemplify the enhancement of our model we calculate the optimized site distribution for the isolated and the integrated approach and compare the risk adjusted costs of the original site distribution with the risk adjusted costs of the site distribution resulting from our model. These optimized allocations are compared with the ones originally chosen by ACME.

Results

Using an implemented Java program we simulated the two efficient frontiers by building 287,496 possible SPC-portfolios for both the isolated and the integrated approach by iterating in 10% steps through feasible site allocations for each project and calculating expected costs and risks for each portfolio using equations 2) and 3) (see Figure 2, each black dot represents a specific portfolio). Possible portfolios of the integrated and isolated approach are shown

in the left and right hand side scatter plot, respectively. All portfolios at the outer left side of each scatter plot are not dominated by other portfolios and, thus, form the efficient frontiers.
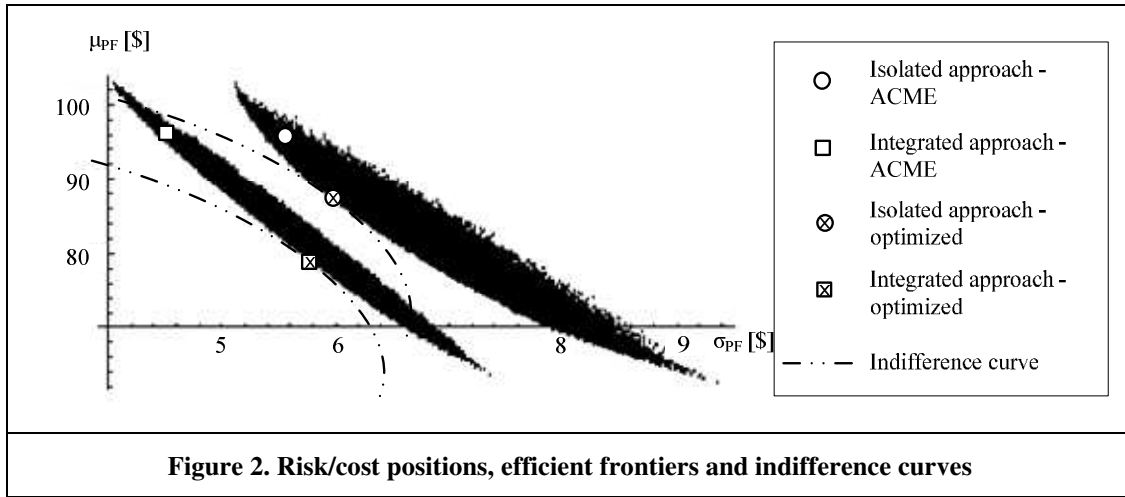

Figure 2. Risk/cost positions, efficient frontiers and indifference curves

But only one portfolio for each approach is optimal for the decision maker and located exactly at the tangential point of the respective indifference curve representing the preferences of the decision maker. Basically, the optimal portfolio could have been calculated using 5) in parallel to the simulation procedure and taking the portfolio with the highest value of the applied preference function. However, to be more granular than in the efficient frontier simulation and to reduce computation time because we found the 10% steps were sufficient for the simulation, but not to find the optimal portfolio, we calculated the two optimized portfolios by implementing the heuristic proposed by Buhl and Heinrich (2008). For a comparison, the risk/cost positions of the originally chosen (given) allocation by ACME are illustrated with the blank circle (isolated approach) and blank quadrate (integrated approach). The optimized allocations are represented by the circle filled with the cross (isolated approach) and the quadrate filled with the cross (optimized approach). The optimized allocation of the projects as well as the original allocation of ACME and the resulting values of μ_{PF}, σ_{PF} and Φ_{PF} for both approaches are also shown in Table 8.

Table 8. Results of the different approaches						
	Isolated approach			Integrated approach		
ACME	*m*=1	*m*=2	*m*=3	*m*=1	*m*=2	*m*=3
n=GER / CZ / IND [%]	80 / 20 / 0	75 / 0 / 25	67 / 0 / 33	80 / 20 / 0	75 / 0 / 25	67 / 0 / 33
μ_{PF} [$]	95.36			95.36		
σ_{PF} [$]	5.67			4.57		
Φ_{PF} [$]	-50,979,110			-46,497,859		
OPTIMIZED	*m*=1	*m*=2	*m*=3	*m*=1	*m*=2	*m*=3
n=GER / CZ / IND [%]	39 / 31 / 30	55 / 24 / 21	55 / 24 / 21	15 / 40 / 45	41 / 0 / 59	21 / 35 / 44
μ_{PF} [$]	89.33			79.16		
σ_{PF} [$]	5.98			5.79		
Φ_{PF} [$]	-50,042,237			-45,092,467		

The site distributions of ACME for both approaches neither lie on the specific efficient frontiers nor fit to their level of risk aversion because the risk/cost positions of the original portfolio is not situated on the best indifference curve possible. The fact that the efficient frontier of the integrated approach in Figure 2 dominates the efficient frontier of the isolated approach leads to the first result.

Result 1: *The way ACME is making sourcing decisions isolated for each project (and as discussed with several executives of ITSP as usual in practice) leads to a suboptimal site allocation caused by neglecting diversification effects between projects and sites.*

We must admit, though, that the optimized allocation may usually not be converted unmodified to a real allocation. Since software development projects can not always be cut arbitrarily as assumed before, a relaxation of this assumption is necessary: The optimal allocation can be taken as reference and an allocation lying in close proximity to the optimal one can be chosen. Such modifications without large deviations from the optimized result generally do not cause a substantial change of the overall risk/cost position (cf. Sensitivity Analysis). Still, with this relaxation it is not for sure, that the chosen allocation is the best possible one.

In the context of this specific example we can state that a holistic valuation of all IT projects allows for realizing (risk adjusted) cost reduction potential. Treating the projects as a portfolio leads to 9% lower risk adjusted costs, if the results of the isolated and the integrated approaches concerning the original distribution are compared. In Figure 2 this is illustrated by the dominance of the "Integrated approach – ACME" over the "Isolated approach – ACME". The pure diversification effect is visible there because the same site distribution is assumed for both approaches. However, an optimization considering diversification effects between sites and projects leads to a completely different site distribution (cf. Table 8). The optimized isolated approach calculates a distribution with 2% lower risk adjusted costs in comparison to the valuation of ACME. Comparing ACME's and the optimized allocation of the integrated approach, the optimized allocation delivers even 10% lower risk adjusted costs. Analyzing the new allocation resulting from the optimized integrated approach shows that 3% lower risk adjusted costs may be realized compared to the optimized isolated approach and actually 12% compared to the isolated ACME approach. Obviously, ACME has not capitalized on all risk adjusted cost reduction potentials so far.

By examining only the expected LOC-costs both optimized portfolios show substantially lower costs by exploiting the risk carrying capacity of ACME. The costs would decrease by 6% for the isolated and even 17% for the integrated valuation. For example, assuming that ACME has a net profit ratio of 10%, the net profit ratio would increase to 15% for the portfolio optimized with the isolated approach and to 24% for the portfolio optimized with the integrated approach. Thus, an optimal site allocation may help to realize enormous cost reduction potential by an acceptable level of increase in risk what leads to the second result based on the example at hand.

Result 2: *Optimizing the site allocation by considering diversification effects between projects and sites may help ITSP to realize significant cost savings by treating its set of IT projects as a portfolio and exploiting its risk carrying capacity.*

Based on our discussions with the ACME and other ITSP in the market, we know that most of them use similar methods to valuate their sourcing decisions as ACME did so far. Hence, the results presented above underscore the need to implement company wide IT Sourcing Portfolio Management including methods considering the interdependencies not only between projects but also between sites.

Sensitivity Analysis

In practice parameter estimations obviously bear failure potential, e.g. executives misjudge potential outcomes or probabilities or do not have sufficient information. To get a feeling for the robustness of the results applying our model, we accomplished a sensitivity analysis changing one input parameter by ±5% c.p. and determined new optimized integrated portfolios (cf. Table 9). Thus, we can, firstly, compare the new with the initial allocation and, secondly and more interestingly, compare the new portfolio costs $\mu_{PF,new}$ and risk $\sigma_{PF,new}$ with the costs $\mu_{PF,old}$ and risk $\sigma_{PF,old}$ that would result by using the changed parameter but the optimized integrated allocation (cf. Table 8) based on the initial parameter value estimations. The latter comparison helps us in determining how severely an incorrect estimation affects the overall outcome.

Apparently, the allocation is sensitive to variations (c.p.) of LOC-costs, risks and the Arrow-Pratt parameter, while for the other analyzed parameters the allocation is broadly stable. More important, comparing the new and old expected portfolio costs and risks, we can see that the only substantially different results occur if the Arrow-Pratt parameter is estimated incorrectly, all other results are pretty much stable. Hence, an ITSP should invest much effort and time to determine the Arrow-Pratt parameter to avoid its false estimation and to get high quality results. But this is encouraging since the Arrow-Pratt parameter has to be determined only once and can be applied company-wide over a longer period, while all other parameters have to be estimated for each project and site.

Table 9. Sensitivity analysis for the optimized integrated approach								
Parameter Original value	Modified values	$\mu_{PF,old}$	$\sigma_{PF,old}$	$\mu_{PF,new}$	$\sigma_{PF,new}$	m=1 [%] GER/CZ/IND	m=2 [%] GER/CZ/IND	m=3 [%] GER/CZ/IND
Original optimization		79.16	5.78	-	-	15 / 40 / 45	41 / 0 / 59	21 / 35 /44
LOC_2 80,000/year	76,000 84,000	79.06 79.26	5.78 5.80	78.98 79.34	5.79 5.79	16 / 39 / 45 14 / 40 / 46	39 / 0 / 62 42 / 0 / 58	20 / 35 / 45 21 / 35 / 44
$E(\tilde{C}_{IND,3})$ 70.98	70.98 74.53	78.71 79.64	5.78 5.78	77.86 80.32	5.79 5.72	16 / 39 / 45 14 / 40 / 46	43 / 0 / 57 38 / 0 / 62	14 / 32 / 54 27 / 38 / 62
$\sigma_{CZ,3}$ 8.46	8.056 8.882	79.16 79.16	5.76 5.82	78.41 79.93	5.83 5.73	14 / 40 / 46 14 / 40 / 46	38 / 0 / 62 36 / 0 / 64	4 / 55 / 42 49 / 0 / 51
$C^f_{CZ,1}$ 110,000	99,000 121,000	79.16 79.16	5.78 5.78	79.16 79.16	5.78 5.78	15 / 40 / 45 15 / 40 / 45	41 / 0 / 59 41 / 0 / 59	21 / 35 / 44 21 / 35 / 44
$\rho_{(GER,m),(CZ,m)}$ 0.69	0.657 0.725	79.16 79.16	5.78 5.79	78.86 78.87	5.81 5.82	16 / 39 / 45 13 / 41 / 46	40 / 0 / 60 41 / 0 / 59	21 / 35 / 44 19 / 36 / 45
a 2.0	1.9 2.1	79.16 79.16	5.78 5.78	76.59 81.04	6.02 5.63	10 / 41 / 48 20 / 37 / 43	1 / 40 / 59 46 / 0 / 54	17 / 36 / 47 26 / 33 / 41

Conclusion

Potentials of offshore outsourcing are intensely discussed in research and practice. However, there is still little research in quantitative IT Sourcing Portfolio Management available so far. Therefore, in this contribution a risk/cost integrating model to support the decision process of ITSP for their software development projects is proposed. In comparison to conventional approaches currently used by ITSP the suggested method comes up with several enhancements. It simultaneously considers not only transaction costs but also risks and interdependencies between projects as well as the involved sites. Applying the model the results provide for an optimal allocation of software development projects over available sites also taking into account fixed costs of the respective sites. On the basis of data about three projects – provided by a major ITSP in the market – the applicability of the approach is illustrated. Moreover, potential enhances with respect to the site distribution of an ITSP are revealed.

In practice sourcing decisions are made isolated for each project. Based on a number of assumptions, we found that our model operationalized on isolated projects leads to a better site distribution and lower risk adjusted costs in comparison to site distributions assessed with conventional methods. The main reason for this result is the consideration of diversification effects among sites, which have not been taken into account by state-of-the-art methods. The consideration of diversification effects among projects leads to a further improvement of the results. Hence, the company-wide implementation of our model to support sourcing decisions may help to achieve an optimized site allocation. At the same time these companies have the possibility to realize cost reduction potential and consequently can either generate higher margins or strengthen their market position by a more competitive pricing.

Furthermore there is still ample potential for extension of the model. First, assuming contractually fixed income provided for by the clients of ITSP neglects their uncertainty. However, apart from fixed incomes other contract types or situations are possible such as time-and-material contracts where the incomes are uncertain depending on progress and success (Gopal et al. 2003) or the loss of income caused by insolvency of the client. Thus, a next step may be the integration of uncertainty of incomes. Second, we assumed infinitely divisible projects. Obviously, in reality IT projects cannot always be cut as postulated by the optimized results. Still, most projects can be cut in a number of functional modules that may be implemented at different sites. Thus, the efficient frontier is just an approximation for the solution space and the set of feasible solutions is rather discrete than continuous. Thus, based on the project characteristics feasible discrete solutions lying near the theoretical optimum have to be evaluated in order to find the best solution for a specific case. Apparently, this solution may not lie on the efficient frontier anymore. Third, the model is just applicable for software development projects. The maintenance of operating IT assets offshore is very popular in practice, too (Hirschheim et al. 2004). Hence planning the site distribution of IT assets is another major task of IT Sourcing Portfolio Management. If both projects and assets would be integrated in the model, a (more) complete IT portfolio may be evaluated.

References

Ang, S., and Straub, D.W. "Production and Transaction Economies and IS Outsourcing: A Study of the U. S. Banking Industry," *MIS Quarterly* (22:4), December 1998, pp. 535-552.

Apte, U.M., Sobol, M.G., Hanaola, S., Shimada, T., Saarinen, T., Salmela, T., and Vepsalainen, A.P.J. "IS outsourcing practices in the USA, Japan and Finland: a comparative study," *Journal of Information Technology* (12:4), December 1997, pp. 289-304.

Aron, R., Clemons, E.K., and Reddi, S. "Just Right Outsourcing: Understanding and Managing Risk," *Journal of Management Information Systems* (22:2), Fall 2005, pp. 37-55.

Arrow, K.J. "The Theory of Risk Aversion", in Arrow, K.J. (Ed.): *Essays in the Theory of Risk-Bearing*, North-Holland, Amsterdam, Netherlands, 1970, pp. 90-120.

Aspray, W., Mayadas, F., and Vardi, M.Y. (Ed.) *Globalization and Offshoring of Software. A Report of the ACM Job Migration Task Force*, Available: http://www.acm.org/globalizationreport/pdf/fullfinal.pdf, Download 2007-02-09, 2006.

Asundi, J., and Kazman, R. "A Foundation for the Economic Analysis of Software Architectures", in *Proceedings of the 3rd Workshop on Economics-Driven Software Engineering Research (EDSER-3)*, Toronto, Canada, May 2001.

Aubert, B.A., Patry, M., and Rivard, S. "Assessing the Risk of IT Outsourcing", in *Proceedings of the 31st Annual Hawaii International Conference on System Sciences*, 6, Hawaii, Hawaii, January 1998, pp. 685-692.

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

Bannister, F., and Remenyi, D. "Acts of faith: instinct, value and IT investments decisions," *Journal of Information Technology* (15:3), September 2000, pp. 231-241.

Barthelemy, J., and Geyer, D. "IT Outsourcing: Evidence from France and Germany," *European Management Journal* (19:2), April 2001, pp. 195-202.

Boehm, B.W., Abts, C., Windsor Brown, A., Chulani, S., Clark, B.K., Horowitz, E., Madachy, R., Reifer, D., and Steece, B. *Software Cost Estimation with COCOMO II*, Upper Saddle River, New Jersey, 2000.

Boston Consulting Group *NASSCOM-BCG Innovation Report 2007*, Available: http://www.nasscom.in/Nasscom/templates/NormalPage.aspx?id=51910, Download 2007-11-27, 2007.

Buhl, H.U., and Heinrich, B. "Valuing Customer Portfolios under Risk-Return-Aspects: A Model-based Approach and its Application in the Financial Services Industry," *Academy of Marketing Science Review* (12:5), Available: http://www.amsreview.org/articles/buhl05-2008.pdf, Download 2008-04-29, 2008.

Butler, S., Chalasani, P., Jha, S., Raz, O., and Shaw, M. "The Potential of Portfolio Analysis in Guiding Software Decisions", in *Proceedings of the 1st Workshop on Economics-Driven Software Engineering Research (EDSER-1)*, Los Angeles, California, May 1999.

Cardozo, R.N., and Smith, D.K. "Applying Financial Portfolio Theory to Product Portfolio Decisions: An Empirical Study," *Journal of Marketing* (47:2), Spring 1983, pp. 110-119.

Carmel, E., and Tjia, P. *Offshoring Information Technology - Sourcing and Outsourcing to a Global Workforce*, Cambridge University Press, Cambridge, UK, 2005.

Courant, R., and John, F. *Introduction to Calculus and Analysis - Volume One*, John Wiley & Sons, Inc., New York, New York, 1965.

Cusumano, M., MacCormack, A., Kemerer, C.F., and Crandall, B. "Software development worldwide: the state of the practice," *IEEE Software* (20:6), November/December 2003, pp. 28-34.

Davidson, D. "Offshore outsourcing subtleties", *Meta Group Report*, March 2003.

DiamondCluster Intenational, Inc. 2005 *Global IT Outsourcing Study*, Available: http://exchange.diamondconsultants.com/pdf/discover/DiamondCluster2005OutsourcingStudy.pdf, Download 2007-06-14, 2005.

Dibbern, J., Goles, T., Hirschheim, R.A., and Jayatilaka, B. "Information Systems Outsourcing: A Survey and Analysis and Literature," *The DATA BASE for Advances in Information Systems* (35:4), October 2004, pp. 6-102.

Dibbern, J., Heinzl, A.H., and Winkler, J. "Offshoring of Application Services in the Banking Industry – A Transaction Cost Analysis", Working Paper 16/2006, Available: http://wifo1.bwl.uni-mannheim.de/fileadmin/files/publications/Working_Paper_16-2006.pdf, Download 2007-03-01, 2006.

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

Everest Research Institute (Ed.) *Global Sourcing Annual Report 2005*, Dallas, Texas, 2005.

Franke, G., and Hax, H. *Finanzwirtschaft des Unternehmens und Kapitalmarkt*, Springer, Berlin, Germany, 2005.

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

Gannon, B., and Wilson, D. "IS Offshoring: A proposed Maturity Model of Offshore IS Suppliers", in *Proceedings of the 15 th European Conference on Information System (ECIS)*, Österle, H., Schelp J., and Winter R. (Ed.), St. Gallen, Switzerland, June 2007, pp. 950-960.

Gellrich, T., and Gewald, H. "Sourcing, Risk and the Financial Market", in *Proceedings of the 13th European Conference on Information Systems*, Bartmann, D., Rajola, F., Kallinikos, J., Avison, D., Winter, R., Ein-Dor, P., Becker, J., Bodendorf, F., and Weinhardt, C. (Ed.), Regensburg, Germany, May 2005, pp. 700-711.

Gopal, A., Sivarama, K., Krishnan, M.S., and Mukhopadhyay, T. "Contracts in Offshore Software Development: An Empirical Analysis," *Management Science* (49:12), December 2003, pp. 1671-1683.

Hajidimitriou, Y.A., and Georgiou, A.C. "International site selection decisions using multi-objective methods," *American Business Review* (18:2), June 2000, pp. 87-95.

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

Haug, P. "A Multiple-Period, Mixed-Integer-Programming Model for Multinational Facility Location," *Journal of Management* (11:3), Fall/Winter 1985, pp. 83-96.

Hirschheim, R.A., George, B., and Wong, S.F. "Information Technology Outsourcing: The Move Towards Offshoring," *Indian Journal of Economics and Business*, Special Issue 2004, pp. 103-124.

Hirschheim, R.A., and Lacity, M.C. "The Myths And Realities Of Information Technology Insourcing," *Communcations of the ACM* (43:2), February 2000, pp. 99-107.

Hodder, J.E., and Dincer, M.C. "A multifactor model for international plant location and financing under uncertainty," *Computers & Operations Research* (13:5), November 1986, pp. 601-609.

Jeffery, M., and Leliveld, I. "Best Practice in IT Portfolio Management," *MIT Sloan Management Review* (45:3), Spring 2004, pp. 41-49.

Katzmarzik, A., Zimmermann, S., and Kundisch, D. "A COCOMO based Approach to IT Sourcing Portfolio Management", WI-IF Discussion Paper WI-230, Available: http://www.wiwi.uni-augsburg.de/bwl/buhl/dyn/root_wissenschaft/030Publikationen/pdf/wi-230.pdf?rnd=78821, Download 2008-04-12, April 2008.

Kersten, B., and Verhoef, C. "IT Portfolio Management: A Banker's Perspective on IT," *Cutter IT Journal* (16:4), April 2004, pp. 27-33.

Kliem, R. "Managing the Risks of Offshore IT Development Projects," *Information Systems Management* (21:3), Summer 2004, pp. 22-27.

Kundisch, D., Sackmann, S., and Ruch, M. "E-Tailers and their Customer Portfolio – A Risk Perspective", in *Proceedings of the 3rd International Workshop on Enterprise Applications and Services in the Finance Industry, Lecture Notes in Business Information Processing*, Veit, D., Kundisch, D., Weitzel, T., Weinhardt, C., Rabhi, F.A., and Rajola, F. (Ed.)*,* Springer, Berlin, Germany, 2008, pp. 32-49.

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

Lacity, M.C., and Willcocks, L. "An empirical investigation of information technology sourcing practices: Lessons from Experience," *MIS Quarterly* (22:3), September 1998, pp. 363-408.

Lacity, M.C., and Willcocks, L. "IT Sourcing reflections – Lessons for customers and suppliers," *Wirtschaftsinformatik* (45:2), April 2003, pp. 115-125.

Lammers, M. "Make, Buy or Share: Combining Resourced Based View, Transaction Cost Economics and Production Economics to a Sourcing Framework," *Wirtschaftsinformatik* (46:3), June 2004, pp. 204-212.

Levina, N., and Ross, J. "From the vendor's perspective: exploring the value proposition in information technology outsourcing," *MIS Quarterly* (27:3), September 2003, pp. 331-364.

Markowitz, H.M. "Portfolio Selection," *The Journal of Finance* (7:1), February 1952, pp. 77-91.

McFarlan, F.W. "Portfolio approach to information systems," *Harvard Business Review* (59:5), May 1981, pp. 142-150.

Min, H., and Melachrinoudis, E. "Dynamic Location and Entry Mode Selection of Multinational Manufacturing Facilities under Uncertainty: A Chance-constrained Goal Programming Approach," *International Transactions in Operational Research* (3:1), January 1996, pp. 65-76.

Moore, M., Kazman, R., Klein, M., and Asundi, J. "Quantifying the Value of Architecture Design Decisions: Lessons from the Field", in *Proceedings of the 25th International Conference on Software Engineering (ICSE '03)*, Portland, Oregon, May 2003, pp. 557-562.

Nasscom (Ed.) *Indian IT Industry Factsheet*. Available: http://www.nasscom.in/upload/5216/ Strategic_Review_Feb2008.pdf, Download 2008-06-28, 2008.

Oh, L.-B., Ng, B.L.-T., and Teo, H.-H. "IT Portfolio Management: A Framework for making Strategic IT Investment Decisions", in *Proceedings of the 15th European Conference on Information System (ECIS)*, Österle, H., Schelp J., and Winter R. (Ed.), St. Gallen, Switzerland, June 2007, pp. 1265-1275.

Patel, N.R., and Subrahmanyam, M.G. "A Simple Algorithm for Portfolio Selection with Fixed Transaction Costs," *Management Science* (28:3), March 1982, pp. 303-314.

Pogue, G.A. "An Extension of the Markowitz Portfolio Selection Model to Include Variable Transactions' Costs, Short Sales, Leverage Policies and Taxes," *The Journal of Finance* (25:5), May 1970, pp. 1005-1027.

Poppo, L., and Zenger, T. "Testing alternative theories of the firm: transaction cost, knowledge-based, and measurement explanations for make-or-buy decisions in information services," *Strategic Management Journal* (19:9), September 1998, pp. 853-877.

Rottman, J.W., and Lacity, M.C. "Twenty Practices for Offshore Sourcing," *MIS Quarterly Executive* (3:3), September 2004, pp. 117-130.

Santhanam, R., and Kyparisis, G.J. "A decision model for interdependent information system project selection," *European Journal of Operational Research* (89:2), March 1996, pp. 380-399.

Schaaf, J., and Weber, M. *Offshoring Report 2005 – Ready for take-off*, Available: http://www.dbresearch.com/ PROD/DBR_INTERNET_EN-PROD/PROD0000000000188986.pdf, Download 2008-02-09, July 2005.

Schneeweiss, H. *Entscheidungskriterien bei Risiko*, Springer, Berlin, Germany, 1967.

Standish Group International, Inc. (Ed.) *2004 Third Quarter Report*, Available: http:// www.standishgroup.com/sample_research/PDFpages/q3-spotlight.pdf, Download 2005-12-27, 2004.

Timpe, C.H., and Kallrath, J. "Optimal planning in large multi-site production networks," *European Journal of Operational Research* (126:2), October 2000, pp. 422-435.

Verhoef, C. "Quantitative IT portfolio management," *Science of Computer Programming* (45:1), October 2002, pp. 1-96.

Weill, P., and Aral, S. "IT Savvy Pays Off: How Top Performers Match IT Portfolios And Organizational Practices", MIT CISR Working Paper No. 353, 2005.

Winkler, J.K., Dibbern, J., and Heinzl, A.H. "Success in Offshoring of Application Development – Does Culture matter?", in *Proceedings of the 14th European Conference on Information System (ECIS)*, Ljunberg, J., and Andersson, M. (Ed.), Göteborg, Sweden, June 2006, pp. l640-1650.