University of Augsburg
Prof. Dr. Hans Ulrich Buhl
Research Center
Finance & Information Management
Department of Information Systems
Engineering & Financial Management

Universität
Augsburg
University

Discussion Paper

Benefits Quantification in IT Projects

by

Martina Beer, Gilbert Fridgen, Hanna-Vera Müller, Thomas Wolf

presented at: 11th International Conference on Wirtschaftsinformatik, Leipzig, February 2013

WI-403

Universität Augsburg, D-86135 Augsburg
Visitors: Universitätsstr. 12, 86159 Augsburg
Phone: +49 821 598-4801 (Fax: -4899)
www.fim-online.eu

Benefits Quantification in IT Projects

Martina Beer[*], Dr. Gilbert Fridgen[*], Hanna-Vera Mueller[*], and Thomas Wolf[*]

[*] FIM Research Center, University of Augsburg, 86135 Augsburg, Germany
{martina.beer,gilbert.fridgen,hanna.mueller,thomas.wolf}@wiwi.uni-augsburg.de

Abstract:

The probability of IT project failures can be mitigated more successfully when discovered early. To support an early detection, transparency regarding a project's cash flows shall be increased. Therefore, an appropriate analysis and calculation of a project's costs, benefits, risks and interdependencies is inevitable. Until today, however, a method that appropriately considers these factors when estimating the ex ante project business case does not yet exist. Using the Action Design Research approach, we designed, applied and tested a practicable and integrated method of determining the monetary value of IT projects to generate generalized insights to benefits management. This method was conjointly developed by practice and academia, to ensure practical applicability while upholding scientific rigor. Furthermore, to support understandability of the method, we provide an application example.

Keywords: Benefits Quantification, Value Assurance, Business Value of IT, Quantitative Method, Action Design Research

1 Motivation

Companies continuously increased their IT investments over the last decades. According to Gartner [10] this trend is about to continue. In this context, especially the number and complexity of large IT projects is growing. The complexity is intensified by dependencies within one or between different projects and processes and is boosted even further by the growing number of large projects. Another important influence is the rising uncertainty in an increasingly dynamic project management environment.

Flyvbjerg and Budzier found that one out of six IT projects causes budget deficits of 200% on average [7]. In several cases this can even threaten the existence of the assigning company. Amongst others, reasons for the failure are IT specific risks concerning project evaluation, like for example misjudgment of user acceptance or changing security requirements of the new system. Another reason is the lack of recognition of different kinds of interdependencies [23]. However, according to Flyvbjerg and Budzier [7], the continuous measurement and controlling of expected projects benefits seems to be positively related to IT project success. Whereas project costs are already measured elaborately by several practicable methods like the Constructive Cost Model of Boehm [6], corresponding methods concerning the management of an IT project's benefits just barely exist. Usually, that is because benefits of a project can oftentimes just hardly be quantified or transformed into monetary values. Moreover, in most cases benefits are not realized until a project has been completed. Therefore, the quantification of benefits in practice is mostly conducted using qualitative and rarely quantitative but especially no monetary procedures. In this challenging context, practice demands for an approach incorporating costs, benefits, risks, and interdependencies. The use of such an integrated approach, which can be embedded in a continuous project controlling to compare the monetary results over time, enables a company to detect relevant deviations from target goals. Based on that, corresponding control measures can be taken, which reveal the need and allow for corrective actions to reduce the probability of IT project failure.

Therefore, the objective of this paper is to introduce an integrated method, which considers costs, benefits, risks, and interdependencies and is, beyond that, easily applicable in practice. For the development of this method, we decided to use an Action Design Research (ADR) approach [18]. Specific for this research approach is the simultaneous development and the evaluation of an (IT) artifact, which is done in mutual cooperation between practitioners and researchers. Due to the need of companies to evaluate IT projects more holistically and the lack of methods being available and applicable in practice, one of the world's leading strategy consulting companies (in the following referred to as CC) pointed out their need for a methodically sound as well as easy to use method of benefit quantification for IT projects. Therefore, the Research Center Finance & Information Management (FIM), developed an approach to benefits management collaboratively, gathering feedback from practice regarding efficacy and applicability of the method on a regular basis and upholding scientific rigor. Furthermore, we tested the developed method at an industrial client, namely a multinational manufacturing company (in the following referred to as MC), who used the method to evaluate benefits of multiple mobile app development projects. The valuable feedback of both business partners, CC as well as MC, gave us the opportunity to satisfy the criteria of an Action Design Research process and to develop an artifact which fulfills the requirements of all stakeholders from business practice and science.

Figure 1 shows the ADR approach based on the depiction in Sein et al. [18], adjusted to our specific project setting.

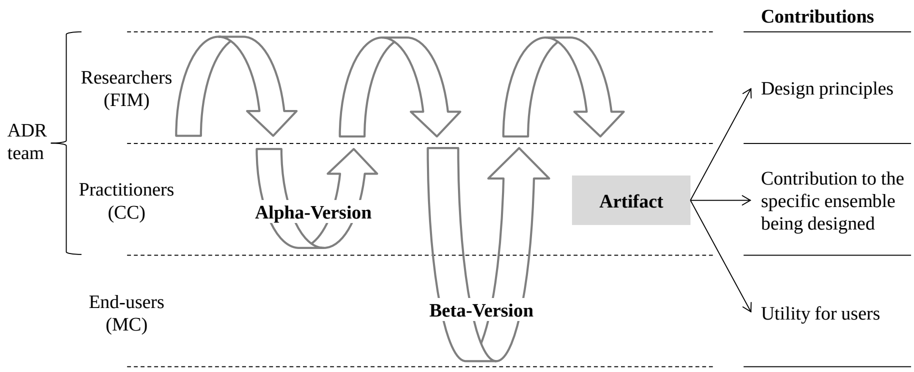

Fig. 1 - Building, Intervention and Evaluation Scheme in ADR (cf. Sein et al. [18])

Since the objective of ADR is to generate prescriptive design knowledge by developing and evaluating an artifact[1] in cooperation with business partners, it seems to be the most suitable research method for this topic. The ADR approach is divided into four stages: at the first stage, which is called *Problem Formulation* (cf. section 2), the research problem is motivated by input from science and practice, i.e. the need for benefits management as indicated by our business partners, combined with the lack of corresponding approaches in science. At the second stage *Building, Intervention and Evaluation* (cf. section 2), the initial artifact is designed, evaluated and improved at the same time by its application through practitioners (Alpha-Version loop) and end-users (Beta-Version loop). *Reflection and Learning* representing stage three of the ADR approach matches the first two stages and has the objective, to reflect and increase the understanding of the artifact. In our case, learning and reflection are represented by the feedback of the practitioner and end-user, and can be found in section 3 and in the application example given in section 4. In the last stage *Formalization of*

[1] According to Sein et al. [18], the artifact is a piece of hardware and/or software and hence is referred to as IT artifact. Although, we also implemented an IT driven tool for the management of benefits, we focus on the methodical approach which has been developed in this paper.

Learning (cf. section 5) the artifact should be further improved for more generalized concepts, called design principles.

2 Problem formulation

As described above, existing approaches to benefits management oftentimes account for qualitative factors, only. Some models establish quantification of benefits and sometimes also risks, but not on a monetary basis. In the following, we shortly present existing approaches to benefits management like they can be found via a thorough analysis of IT project management literature. Since the scope of this paper is specifically on quantitative methods for IT project valuation, we focused on these kinds of approaches, although we are aware that lots of publications are heading in the direction of benefits management more generally.

The scoring model [24] firstly identifies all relevant evaluation criteria of a specific project. These criteria are weighted by assigning specific scores. The scores indicate different levels of importance for decision-makers. Subsequently, a user value is calculated by multiplying the criteria by the corresponding weighting and aggregating them to an overall value. This allows for a comparison of the different alternatives. In the WARS-Model[2] [15] estimated benefits and costs are subdivided into three categories according to their tangibility. Each category is allocated with three levels of realization probabilities resulting in separate matrices for benefits and costs. Uncertainty is pictured via the classification into risk stages, representing the optimism or pessimism of a decision-maker. To evaluate projects more quantitatively, Schumann [17] introduces a method based on functional chains, taking benefits up to the level of monetary values by focusing on the consequences of their effects. In this process, benefits are consolidated to categories or allocated to different company levels. Andresen et al. [1] developed a framework to categorize benefits by efficiency, effectiveness and performance. In this context 'efficiency' is calculated as risk-weighted monetary, 'effectiveness' as risk-weighted quantitative but non-monetary, and 'performance' just as a qualitative value with a specific probability of occurrence. Another approach to evaluate IT investments, which is described by Van Grembergen and De Haes [20], is the Balanced Scorecard. In this approach the relations of cause and effect of qualitative and quantitative key figures are described. Two general types of key figures are distinguished: performance drivers and output figures. To evaluate a project, the degree of target achievement is measured for each key figure. For an ex ante evaluation of IT investments Walter and Spitta [22] use the SMART-Model[3]. Though, the course of

[2] Economic Efficiency Analysis with Risk Categories (original term in German: Wirtschaftlichkeitsanalyse mit Risikostufen)
[3] Simple Multi-Attribute Rating Technique

action of this model is in analogy to other scoring models, it additionally gives instructions for the application.

All approaches illustrated above consider benefits and risks to a different extent. However, to the best of our knowledge there exists no integrated approach, fulfilling all of the following requirements:

- Benefits of an IT project have to be considered monetarily.
- The risk associated with a project's benefits has to be considered monetarily.
- When assessing risk, dependencies between benefits have to be considered.
- The approach has to be practically applicable requiring a low level of additional overhead.

The requirement of practical applicability leads us to the adoption of several measures concerning the operationalization of our approach. We developed these measures on the basis of the feedback of our two collaborating business partners, CC and MC. In the following we outline these measures as we derive our model.

3 Model: Monetary Quantification of IT Projects

As mentioned earlier, in today's IT projects a wide range of project evaluation methods are already implemented successfully. Some of them have a strong emphasis on costs, like for example the Constructive Cost Model or Function Point Method [14]. To provide a more integrated evaluation method, as a first step, we focus on benefits of IT projects considering costs but without examining them in detail. In accordance with our business partners, we consequently agreed to the following simplifying assumption:

Assumption 1: A project's costs C are deterministic and known in advance.

Hence, we focus on the accurate identification and evaluation of all relevant benefits of an IT project. In this context a benefit is considered to be either based on a direct or indirect reduction of payouts or on increased revenues. The consideration of non-deterministic costs within our model is subject to further research. Before we are able to derive an overall integrated project value, we first assess each benefit separately regarding monetary contribution and risks.

3.1 Assessment of a Single Benefit

There are quantitative and qualitative benefits of IT projects. Quantitative benefits can directly be measured whereas qualitative benefits are difficult to transform into monetary units [22]. To overcome these difficulties and to ensure the mathematical rigor of our method we chose a cash-flow based approach considering deterministic costs and including benefits as random variables. For a rigor application of our model, benefits need to be assigned without overlaps. In coordination with our business partner CC in the Alpha-Version-loop of the ADR approach, we first assign each benefit to an area in which it occurs, like for example the area of customers or employees, in order to grasp the benefits more holistically and identify possible overlaps.

To estimate the approximate monetary value of the respective benefit, we assume that each benefit can be assessed by a monetarization rule. These monetarization rules can finally be transferred into equations. Exemplarily, the benefit *cost savings through reduction of training times*, is assigned to the area *employees*. The monetarization rule states *increased productivity through shortened training times*. Finally the equation $c_T \cdot \Delta n_T + c_E \cdot \Delta n_E$ can be derived, whereas c_T represents the hourly rate of a trainer T, Δn_T the number of overall saved trainer-hours, c_E the hourly rate of an employee E and Δn_E the number of overall saved training-hours for employees. However, this monetarization rule is just a means of support to raise the decision-maker`s awareness for the variables influencing the specific benefit. The indicated exactness of the calculated value is misleading, as benefits bear uncertainty and risk which has not yet been considered in the quantification.

At this point we received feedback from our collaborative business partner CC, that the estimation of exact parameters for a specific benefit is hardly possible for project staff. However, market-driven parameters indicate that benefits mostly are normally distributed. Based on this input we made the following assumption:

Assumption 2: The monetary values of benefits are uncertain and can be considered as normally distributed random variables $\tilde{b}_i \sim N(\mu_i, \sigma_i)$.

The simplifying assumption of a normal distribution for benefits is justifiable, since benefits depend on market risks and others, which can cause positive and negative deviations. At the same time a normal distribution is mathematically easy to use and allows for an analytical calculation of our objective function as can be seen in section 3.3.

In a first attempt, we tried to directly retrieve the distributional parameters from the decision-makers. Though, CC argued that this approach is not feasible in practice, since these parameters are difficult to comprehend. To simplify the estimation of uncertain benefits, we hence draw back on an acknowledged procedure of behavioral finance, by using an interval-based scheme for the evaluation of each benefit similar to Tversky and Kahneman [19]. The practical operationalization of estimating a lower bound u_i and upper bound o_i of the interval can be done by answering the question: In which range will the value of the benefit be at a specific probability like for example 80%? (cf. Figure 2). We chose an 80% interval according to our business partner’s suggestion. CC argued that an 80% probability is easily graspable by project staff members since it is commonly used in practice.

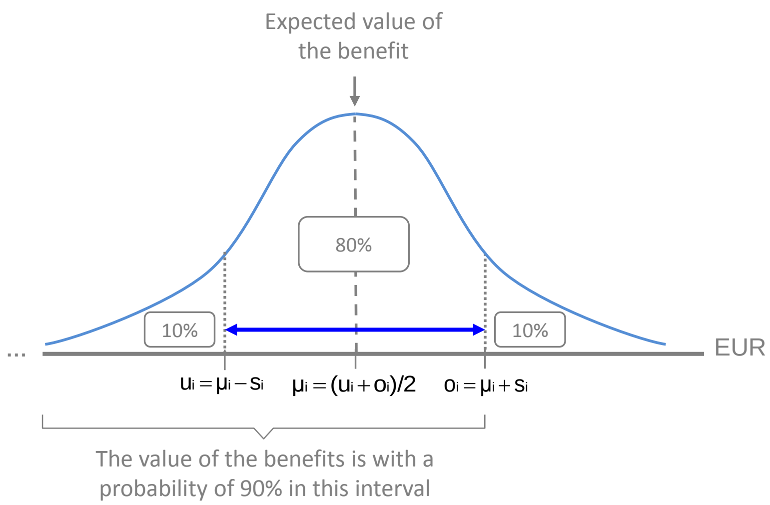

Fig. 2 - Realization-interval of an expected value of a benefit

Based on assumption 2 we are able to derive the expected value μ_i and the standard deviation σ_i of a benefit $\tilde{b}_i$. In accordance to Tversky and Kahneman [19], we assume μ_i to be the mean between u_i and o_i, thus $\mu_i = \frac{(u_i+o_i)}{2}$. We calculate $s_i = o_i - \frac{(u_i+o_i)}{2}$ as the spread between μ_i and the upper and lower bounds respectively. With $F_{0,1}(x)$ as distribution function for the standard-normal distribution and $F(x)$ as the wanted distribution function with $\tilde{b}_i \sim N(\mu_i, \sigma_i)$ we know:

$$F(x) = F_{0,1}\left(\frac{x_i - \mu_i}{\sigma_i}\right) \quad (1)$$

Since it is also known that $F_{0,1}(1{,}28) \approx 90\%$, and in this case $x_i = \mu_i + s_i$ we can constitute: $\frac{x_i-\mu_i}{\sigma_i} = 1{,}28 \Rightarrow \sigma_i = \frac{x_i-\mu_i}{1{,}28} \Rightarrow \sigma_i = \frac{s_i}{1{,}28}$.

In order to obtain mathematical rigor, we therefore derive the parameters μ_i and σ_i for each benefit $\tilde{b}_i$ from the estimated realization interval of the decision-maker. This coherence is also shown in Figure 2.

After identifying all benefits and calculating their expected values and standard deviations, we are now able to aggregate these, in order to derive a distribution of the overall benefits of an IT project.

3.2 Aggregation of a Risk-Adjusted Project Value

We determine the overall expected benefit of an IT project B by aggregating the expected values of each single benefit $\tilde{b}_i \sim N(\mu_i, \sigma_i)$.

$$B = \sum \mu_i \quad (2)$$

To calculate the overall standard deviation of an IT project S, we have to account for dependencies between benefits which, sometimes react similar e.g. to external influences. For example in case of technological innovation multiple benefits might be affected simultaneously. To picture this effect, we constitute the following again simplifying assumption:

Assumption 3: Dependencies between benefits are linear.

Linear dependencies between two benefits $\tilde{b}_i$ and $\tilde{b}_j$ with $i, j = 1 \dots n$ can be measured by the Bravais-Pearson correlation coefficient p_{ij} . We can calculate the overall standard deviation of an IT project S by aggregating the standard deviation of the single benefits and their respective correlation coefficients.

$$S = \sqrt{\sum \sum \sigma_i \sigma_j p_{ij}} \quad (3)$$

The identification of the correlation coefficients between every pair of benefits is a complex task, since a high number of parameters are involved and the context is hard to understand by project staff. As the involved practitioners (CC) suggested, we developed an easier approach for a gradually and guidelined determination of interdependencies. Firstly, we specified a default value, saying all benefits shall be moderately positive correlated. This pre-allocation is intelligible because all benefits occur within one project, wherefore they are at least subject to some kind of dependencies. In case of exceptions, in which the default setting needs to be adapted, corresponding pairs of benefits are identified and alternative correlation values are entered. To facilitate this adjustment, the decision-maker is able to select one of five options outlined in natural language instead of numerical values for the corresponding correlation of two benefits. For example an absolute positive correlation $p_{ij} = 1$, is described by "a high value of benefit $\tilde{b}_i$ always corresponds with a high value of benefit $\tilde{b}_j$". For $i = j$ the correlation coefficient $p_{ij} = 1$.

Given these values, we can obtain a risk-adjusted project value considering costs, benefits, risk, and correlations monetarily. Therefore, we use a preference function which is in line with the Bernoulli principle and developed according to established methods of decision theory [4], [5], [13], [21]. Similar formal approaches and assumptions for risk adjusted economic value analysis have been derived by [12] and have been applied in the context of IT numerous times, for example in [3], [9], [8], [11], and [25]. Therefore we postulate the following assumption:

Assumption 4: The calculation of the risk adjusted project value follows the general structure $\phi(\mu, \sigma) = \mu - \alpha\sigma^2$. We define α as the parameter of risk aversion and assume that the decision-maker is risk-averse ($\alpha > 0$).

The risk adjusted project value can be interpreted as the certainty equivalent for normally distributed random variables and an exponential utility function and thus as an amount of money. The parameter $\alpha > 0$ is a linear transformation of the Arrow-Pratt characterization of absolute risk aversion [2]. The higher the value of α, the more risk-averse is the decision-maker. For practitioners the concept of risk aversion is fairly abstract. Therefore, a precise determination thereof is very difficult. Again, we considered the input of CC and MC and designed a survey to determine a company's parameter of risk aversion at the executive level. Such an approach can also be found in behavioral finance [16]. Thereby the relevant decision makers are asked multiple questions about their maximum willingness to pay for different fictive project settings to determine the risk class, which is afterwards assigned to a corresponding value of risk aversion. Since the outline of every question of this survey would go beyond the scope of this contribution, we refrain from a detailed description and provide an example in section 3.3.

For the calculation of the project's risk-adjusted value we compare deterministic cash outflows $-C$ with the aggregated expected benefits $\sum \mu_i$, adjusted by a risk discount $\alpha \sum \sum \sigma_i \sigma_j p_{ij}$, consisting of the overall standard deviation of an IT project squared and weighted by the parameter of risk aversion α. Hence, we are able to aggregate the risk-adjusted project value according to the following equation:

$$\phi(\mu, \sigma) = -C + \sum \mu_i - \alpha \sum \sum \sigma_i \sigma_j p_{ij} \quad (4)$$

3.3 Application Example

As mentioned earlier, we applied this benefits management approach by using a specifically designed IT tool in a multinational manufacturing company (MC). The following example illustrates this application in a simplified way with altered and anonymized data. This step corresponds to the Beta-Version loop in the ADR approach.

MC operates primarily in the construction industry and has a sales force, which is distributing the company's products directly at the customers' sites. Furthermore, the dynamic pricing system of the company arranges different discounts for different customers. When necessary, sales representatives request current, customer specific prices through the company´s call center directly at the customers' sites. The company is about to launch a mobile app project to facilitate such pricing requests on mobile devices. Therefore, MC wants to calculate the project value under the following premises:

- The observation period is 1 year

- The risk aversion parameter of the decision-maker was determined to be 0,000031
- The total costs of the project are 78,300 € for in-house, external, back-end development, and support
- The identified benefits are:
  - Increased customer satisfaction and loyalty
  - Reduced customer call losses
  - Reduced number of false pricing proceedings
- The correlations between the benefits are all moderately positive

The risk aversion parameter was determined at the executive level, since this parameter is valid not just for this single project but for the whole enterprise. We investigated the risk aversion parameter, as stated in section 3.2, by a survey. The following question is part of this survey and exemplarily illustrates the kind of questions the decision-makers were asked:

Please state your maximum willingness to pay for a risk-mitigating measure in the context of a project with the following characteristics (cf. Figure 3):

- The project has an expected value of 100,000 €
- The expected value deviates with 80% probability by 30,000 €
- The execution of the measure reduces the deviation to 20,000 €

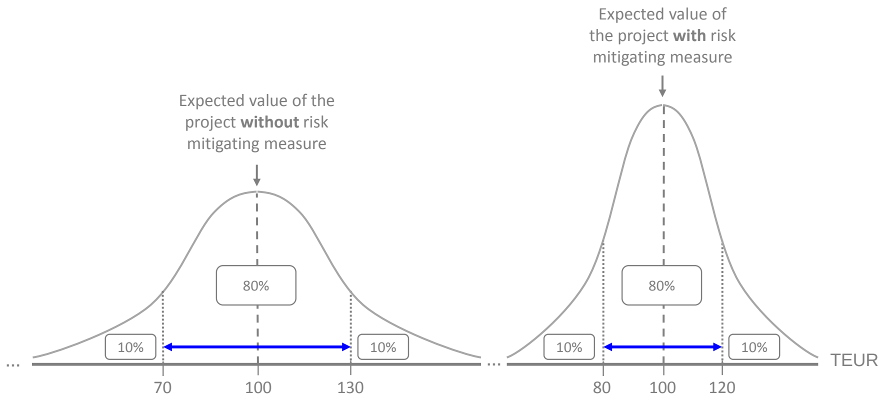

Fig. 3 – Reducing the deviation of an expected project value by risk mitigation4

Based on the maximum willingness to pay z_{max} as outcome of the survey, and the variance before and after (σ^2_{prior} and σ^2_{after}) the risk-mitigating measure, the parameter α can be derived:

[4] An example for a risk mitigating measure could be the purchase of insurance.

$$\alpha = \left(\frac{z_{max}}{\sigma^2_{prior} - \sigma^2_{after}}\right) \tag{5}$$

After the general parameters of the project setting like observation period, deterministic costs and risk attitude have been determined and all benefits have been identified, we were able to estimate an interval for each single benefit.

Benefit 1 is about *increased customer satisfaction and loyalty* and describes reduced customer losses due to the new mobile app. If a sales representative of MC is on the spot at a customer`s and needs to make a quick customized price enquiry, he or she can directly use the mobile app instead of conferring to the call center. Hence, without the app a longer process for pricing requests and longer waiting times would be necessary, which leads to customer dissatisfaction and can even result in customer losses. This coherence can be depicted through the equation $l_c \cdot v_c$ with l_c representing the expected number of customer losses prevented per year, and v_c the average customer value. Based on this monetarization rule, the responsible decision-maker estimated the 80%-interval for the expected value of benefit 1 to be (210,000;375,000) [€].

Benefit 2 is about *reduced customer call losses*. It represents the revenue that is generated through the capability to answer more or even all customer calls. The support center answers calls from customers as well as sales representatives. Due to the use of the mobile app, fewer sales representatives need to confer regarding pricing request and therefore less capacity is tied up at the support center. Consequently, capacity is freed for customer support and therefore fewer calls are missed and a higher number of enquiries can be answered. The corresponding monetarization rule is: $c_l \cdot v_{cc} \cdot \Delta c_l$, whereas c_l is the number of customer calls lost due to higher capacity utilization of the support center in case of pricing requests, v_{cc} is the average value of a customer's call and Δc_l the expected reduction of lost customer calls as a percentage. For benefit 2 the 80%-interval is (25,000;50,000) [€].

The third benefit is the *reduced number of false pricing proceedings*. When a sales representative is at a customers' site, it is possible that the customer has short-term product enquiries. If in that case the representative is not able to confer with the call center, he has no current information about the customer specific product prices and is just able to either estimate the actual price or make an offer based on outdated information. Consequently, if the offered price is lower than the actual one, it comes to revenue losses. Since the mobile app enables real-time price enquiries, these revenue losses can be avoided. In this case, we can derive $p_o \cdot v_o \cdot \Delta p_o$ as monetarization rule for benefit 3, whereas p_o is the average number of price overwrites per year, v_o the average monetary value of a wrong price, and Δp_o the error reduction as a percentage. The resulting 80%-interval for the expected value of benefit 3 is (110,000;280,000) [€].

The expected values μ_i are determined by the mean of the corresponding estimated intervals. Therefore, μ_1 = 292,500 €, μ_2 = 37,500 €, and μ_3 = 195,000 €. The corresponding standard deviations are σ_1 = 64,453 €, σ_2 = 9,766 €, and σ_3 = 66,406 €. Aggregating the expected values of the single benefits lead to an expected project value $B = \sum \mu_i$ of 525,000 € (cf. equation (2)). Taking the risk measures and a slightly positive correlation of 0.5 between all benefits, we calculated a risk discount (cf. equation (4)) of 220,369 €. Considering overall deterministic costs C of 78,300 € we finally got an expected risk-adjusted project value $\phi(\mu, \sigma)$ of 226,331 € (cf. equation (4)) for the mobile app project. Since the risk-adjusted project value is greater than zero, it increases the business value of MC. Therefore, the mobile app project should be launched.

4 Conclusion, Limitations, and Outlook

Unlike existing methods, which do not consider costs, benefits (especially benefits that are hard to quantify), risks and interdependencies between benefits, we introduce an integrated and novel method for benefits quantification in IT projects. According to the ADR cycle, we designed, applied and tested this method in collaboration with practice using real world data for development and constant improvement. Our objective is to generate generalized insights to benefits management by means of our artifact. In the context of our collaborative project, we identified methods, which can measure different project parameters and meet academic standards and preserve practical applicability. Since these methods can be assigned to different kinds of problems, we outline them in the following.

According to our business partners, the estimation of an accurate value for a benefit is difficult in practice. We found that an interval-based scheme according to Tversky and Kahneman [19], which is a method from behavioral science, is a practicable and rigor means to assess the value of a project's benefits.

Another difficulty in practice is the determination of dependencies between benefits. Hence, we developed a simplified procedure, which assumes moderately positive correlations between benefits within the same project and provides an intuitive gradual adaption in exceptional cases in which there are higher or lower correlations between benefits. This procedure therefore meets practical requirements and is compatible with academic concepts.

Decision-makers in practice are oftentimes incapable of assessing their risk aversion. Therefore, we draw back on an approach of behavioral finance, by developing a survey incorporating different questions inquiring the decision-makers willingness to pay in different project settings. This approach enables to derive the value of the decision-makers risk aversion by rigor means.

Finally, the presented method for benefits management constitutes an overall risk-adjusted project value of an IT project, which can be used as an important management control figure for decisions about and within IT projects and therefore is substantial for an overall value-based management.

Besides the introduced ex ante valuation of benefits in a business case, the implementation of this method in a continuous IT project controlling can help to identify deviations between the ex ante business case and the current project value during the course of a project and can therefore indicate needs for actions and support the early detection of IT project failure. The development of a continuous project steering and controlling by the means of the proposed method is our current work in progress. Moreover, the introduced method for benefits management should be further applied and tested in practice with more real world data for constant improvement. The application in practice also assists by setting up a knowledge base in the field of benefits management. This repetitive course of action leads to further improvement and adaptions of our benefits management method.

Our model, however, required several simplifying assumptions. We assumed the costs of an IT project to be deterministic since we focused on the quantification of the benefits. Thus, a more detailed examination of stochastic costs of IT projects is subject to further research. For the calculation of the risk-adjusted project value we consider the standard deviation as measure of risk. This two-sided risk measure scales risk as symmetric deviation of the expected value. Likewise, it is conceivable that the model might be adapted to include different risk measures like Lower Partial Moments or Value at Risk (VaR). In cooperation with our business partners we noticed that especially the VaR is easy to interpret for responsible decision-makers. Moreover, we consider linear dependencies between benefits only, as we picture them by a Bravais-Pearson correlation coefficient. Yet realistically, dependencies between benefits in some cases may also be non-linear. But since this is a complex subject and not satisfactorily solved by academia or practice, it is justifiable to work with this simplifying assumption of linear dependencies in order to derive first results. Furthermore, we assume a moderately positive correlation of benefits by standard, which may not realistically reflect the specific dependencies of all benefits, but at least is feasible due to the fact that these benefits occur within one and the same project. Also the gradual adaption of these dependencies may imply potential for inaccuracy, but is the most appropriate procedure in practice according to our business partners.

Besides the several simplifying assumptions, there are additional limitations of our model. We applied the developed approach to a mobile app project and derived valuable results. However, since it not yet has been applied to different IT projects, varying in scope and size, we cannot consider the approach to be appropriate for miscellaneous IT projects. As this is an important issue to practitioners, it is topic to further research and evaluation. Furthermore, we assume that it is possible to derive a monetarization rule for each benefit. This is also a limitation, as it might be conceivable that there are benefits, which are hard to or even cannot be assessed by monetarization rules.

With the method presented in this paper, we are able to derive generalized insights regarding the interval based estimation of benefits, the inquiry of the correlations between benefits, and the determination of the risk-aversion parameter. They provide a reliable basis for further development. It shall be analyzed for which kind and size of IT projects the presented method is suitable. It is conceivable that there are different requirements to the application of the method and therefore different results for small, middle or large IT projects as well as there might be differences for ERP-, CRM-, or BI-projects. This might be of great significance to practitioners as well as to researchers, who should feel encouraged to investigate for example the integration of non-deterministic cost, non-linear correlations and different kinds of risk measures.

References

1. Andresen, J., Björk, B., Betts, M.: A framework for measuring IT innovation benefits. ITcon. 5, 57 - 72 (2000)
2. Arrow, K. J.: The Theory of Risk Aversion. In: Arrow, K.J. (eds.) Essays in the Theory of Risk-Bearing, pp. 90-120. Markham, Chicago (1971)
3. Bardhan, I., Bagchi, S., Sougstad, R.: Prioritizing a Portfolio of Information Technology Investment Projects. Journal of Management Information Systems. 21, 33-60 (2004)
4. Bernoulli, D.: Exposition of a New Theory on the Measurement of Risk. Econometrica. 22, 23-36 (1954)
5. Bernoulli, D.: Specimen theoriae novae de mensura sortis. Commentarii Academiae Scientarum Imperialis Petropolitanae. 5, 175-192 (1738)
6. Boehm, B. W., Abts, C., Windsor Brown, A., Chulani, S., Clark, B. K., Horowitz, E., Madachy, R., Reifer, D., Steece, B.: Software Cost Estimation with COCOMO II. Prentice Hall PTR, New Jersey (2000)
7. Flyvbjerg, B., Budzier, A.: Why Your IT Project May Be Riskier Than You Think. Harvard Business Review. 89, 23-25 (2011)
8. Fogelström, N., Numminen, E., Barney, S.: Using portfolio theory to support requirements selection decisions. In: 2010 Fourth International Workshop on Software Product Management (IWSPM), pp. 49-52. IEEE, Sydney, (2010)
9. Fridgen, G., Müller, H.: An Approach for Portfolio Selection in Multi-Vendor IT Outsourcing. In: Proceedings of the 32nd International Conference on Information Systems (ICIS), Shanghai, (2011)
10. Gartner: Amplifying the Enterprise: The 2012 CIO Agenda. (2012)
11. Hanink, D. M.: A Mean-Variance Model of MNF Location Strategy. Journal of International Business Studies. 16, 165-170 (1985)
12. Longley-Cook, A. G.: Risk-Adjusted Economic Value Analysis. North American Actuarial Journal. 2, 87-100 (1998)
13. Markowitz, H. M.: Portfolio Selection: Efficient Diversification of Investments. John Wiley & Sons., New York (1959)
14. Mukhopadhyay, T., Vicinanza, S. S., Prietula, M. J.: Examining the feasibility of a case-based reasoning model for software effort estimation. MIS Quarterly. 16, 155-171 (1992)
15. Ott, H. J.: Wirtschaftlichkeitsanalyse von EDV-Investitionen mit dem WARS-Modell am Beispiel der Einführung von CASE. WIRTSCHAFTSINFORMATIK. 35, 522-531 (1993)
16. Sautner, Z., Weber, M., Glaser, M.: What determines how top managers value their stock options?. (2007)
17. Schumann, M.: Wirtschaftlichkeitsbeurteilung für IV-Systeme. WIRTSCHAFTSINFORMATIK. 35, 167-178 (1993)

18. Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R.: Action Design Research. MIS Quarterly. 35, 37-56 (2011)
19. Tversky, A., Kahneman, D.: Judgment under Uncertainty: Heuristics and Biases. Science. 185, 1124-1131 (1974)
20. Van Grembergen, W., De Haes, S.: Measuring and improving IT governance through the balanced scorecard. Information Systems Control Journal. 2, 35-42 (2005)
21. von Neumann, J., Morgenstern, O.: The Theory of Games and Economic Behaviour. Princeton University Press, Princeton (1947)
22. Walter, S. G., Spitta, T.: Approaches to the Ex-ante Evaluation of Investments into Information Systems. WIRTSCHAFTSINFORMATIK. 46, 171-180 (2004)
23. Wehrmann, A., Heinrich, B., Seifert, F.: Quantitatives IT-Portfoliomanagement: Risiken von IT-Investitionen wertorientiert steuern. WIRTSCHAFTSINFORMATIK. 48, 234-245 (2006)
24. Zangemeister, C.: Nutzwertanalyse in der Systemtechnik: Eine Methodik zur multidimensionalen Bewertung und Auswahl von Projektalternativen. Wittemannsche Buchhandlung. (1976)
25. Zimmermann, S., Katzmarzik, A., Kundisch, D.: IT Sourcing Portfolio Management for IT Service Providers - A Risk/Cost Perspective. In: Proceedings of 29th International Conference on Information Systems (ICIS), Paris, (Frankreich) (2008)