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VALUE-BASED PROCESS IMPROVEMENT[1]

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Abstract

For years, "improving business processes" has been and is the primary business priority of IT. In business process management (BPM), common criteria to evaluate the improvement of a process are time, costs, customer satisfaction and output quality. In contrast, the management of companies focuses on increasing the company's value, using a value-based management approach, which is hard to be linked to these criteria. A value-based process improvement can alleviate this drawback by incorporating value-based management into the area of BPM. In this paper we introduce, based on the design science paradigm, an approach that is suitable for the value-based improvement of processes. Demonstrating the feasibility and the advantage of our approach, we show its applicability within a real world scenario and evaluate it by comparing it to a competing work in the field of value-based process management.

Keywords: Process improvement, Design Science Research, Value-based process management

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1 Motivation, Aim, and Contributions

In May 2003, Nicholas G. Carr published his widely debated article “IT Doesn’t Matter” in the Harvard Business Review. In response, Howard Smith and Peter Fingar published the book “IT Doesn’t Matter—Business Processes Do”, in which they critically analyze Nicolas Carr’s article. They state that “*Business processes are the main intellectual property and competitive differentiator manifest in all business activity, and companies must treat them with a great degree of skill and care*.” (Smith and Fingar, 2003) Thus, companies must manage their business processes in an *effective* and *efficient* manner. To do so, one particular important area of business process management (BPM) deals with the improvement of business processes. This is also validated by the recent worldwide survey “Leading in Times of Transition: The 2010 CIO Agenda“ (Gartner, 2010), which interviewed nearly 1,600 CIOs. This yearly performed survey found that since 2004 “improving business processes” has been and is the primary business expectation of IT as well as the top business priority of the CIOs. However, what does “improving” refer to? Is it decreasing the costs of a process, decreasing the processing time, decreasing the risks of a process, increasing the quality of products or services that are the result of a process, all of these together or some other factor? An objective definition of “improvement” within the context of business emerges as the first step in achieving the goal of “improving business processes” from a business view.

Since the 1990s, managers have been striving to increase the value of their companies (Koller et al., 2005), using a value-based management (Coenenberg and Salfeld, 2007; Ittner and Larcker, 2001). Hence, in order to improve a process from a business view, this paper defines “improving business processes” as the change of an existing process (redesign), which increases a company’s value. In order to effectively decide what change of a process will increase said value, decision makers should not only consider the resulting change of the (expected) return[2] of a process, but also the uncertainty of this return. That means, decision makers should also consider risk that is determined by the processes and influences the value of the company (*risk contribution of a process*).

Based on the design science paradigm, this paper aims to develop an effective and efficient value-based model (cp. figure 1) to support decisions on how to improve a process with the goal of increasing the value of a company (value-based process improvement). Such an approach should be crucial when it is necessary to redesign an existing process, for example due to new regulations, to decide how to effectively change the process. This is done by comparing the different changes in the value of a company caused by different possible redesigns (process alternatives). The process alternative that has the greatest increase in the value of a company is the best process alternative to be used.

The following aspects help to achieve this aim and they are the key elements that this paper adds to the existing research in the area of value-based process management:

➊ *The possibility to make decisions at the process level that are in the best interest of a company as a whole with consideration of the risk attitude of a company/person in charge (decision maker):* There are different stakeholders to consider when redesigning a process, for example process analysts, organizational strategists, workflow designers and workflow managers (Lewis et al., 2007), all of which might have different objectives for a redesign. We will show how these stakeholders could select the best process alternative from a company’s point of view at a process level considering the risk attitude of the decision maker.

➋ *An effective approach to consider the impact of a redesign on both the expected return of a company and the risk contribution:* A redesign of a process can have two effects on the value of a company, which can be considered to be a combined (risk-adjusted) figure of the expected return of a company and the risks that are contributed by all activities of a company to its value (*risk*

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[2] In this paper, *return* refers to the uncertain (stochastic) net present value (NPV) of all uncertain future cash flows.

contribution of a company) (Bamberg et al., 2006; Faisst and Buhl, 2005). Both the expected return and the risk contribution can change. For example a decrease in the expected return of a company as a result of a redesign may be acceptable if the risk contribution decreases even more, as this could result in an increase of the company's value. We will present how both quantities need to be considered and combined.

❸ *A model to efficiently decide between process alternatives by only having to account for the differences in the expected returns and the risk contributions of the process alternatives:* In this paper, a process alternative improves an existing process if it increases the value of a company. This already implies that it is not necessary to know the total amount of the value of the company before and after a redesign, but only the difference. This is more efficient, because it is easier, faster and cheaper to determine the difference than the total amount of the values.

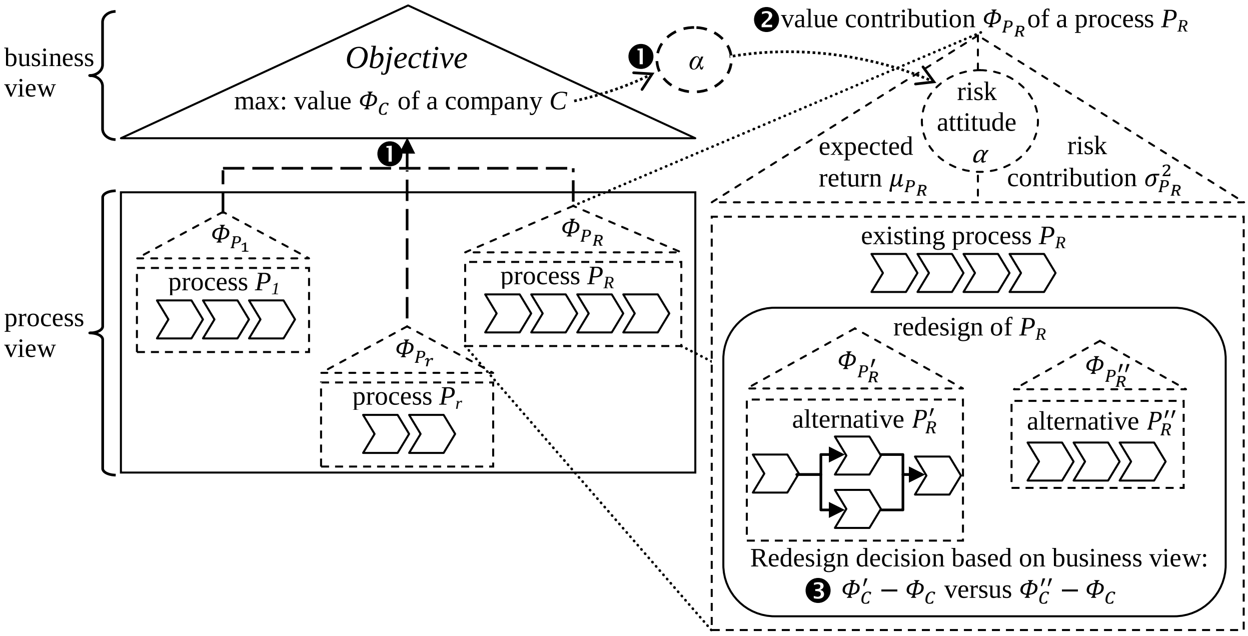

Figure 1. Value-Based Process Improvement

Considering the guidelines for conducting design science research by Hevner et al. (2004) and following the process for design science research in Peffers et al. (2008), we have organized the paper as follows: After having *identified the problem and motivated* its importance in this section, the design process continues in the next section. There, we identify the requirements for our approach which also *define its objectives*. These requirements in combination with a discussion of the related work show the research gap that our approach proposes to fill. Section three answers the key research question of how to perform a value-based process improvement. We *design* an *artifact* that can be used by a technology-oriented audience, and that should be used to *communicate* value-based process improvement to a more general managerial audience. In section four, we *demonstrate* the use of our model by illustrating its application within a real world scenario (*problem instance*). The penultimate section is dedicated to the *evaluation* of our model. Finally, the last section summarizes our considerations and provides an outlook on future steps.

2 Requirements and Related Work

We begin with the formulation of requirements, which the model to perform a value-based process improvement must meet, and that are used during the design process to guide the development of the model. At the same time, these requirements are the source for the subsequent analysis of the related work to identify the need for research. In addition, our proposed model is evaluated against those requirements, after the model has been presented and applied.

2.1 Requirements

The requirements result from the preceding remarks and stem from the area of value-based management. They are listed as follows:

(R1) *Multiple periods*: When comparing alternative processes it is not enough to consider only the current or a single period cash flow, but also future cash flows and multiple periods. A process might have a higher cash flow than another process when just looking at one period, which could lead to wrong decisions if a lower cash flow would result from a comparison over several periods.

(R2) *Objective function of a company*: A model for a value-based process improvement focuses on the increase of the value of a company. Therefore, an objective function, representing that value of a company as a combined figure of the expected return of a company and a risk contribution, is required, which takes the value that a process contributes to a company (*value contribution of a process*) into account.

(R3) *Decision at the process level in the interest of the company:* As mentioned, there are different stakeholders during a redesign, all with different attitudes towards risk. It must be possible for them to decide in the best interest of the company, considering the risk aversion of the decision maker even at the process level.

While (R1) and (R2) are obvious requirements, we take a closer look at (R3). For instance, if a manager that is risk neutral needs to redesign a process of his department, he would disregard a potential risk contribution that is caused by the redesign and focus only on the expected return. In contrast, the CEO with its averse attitude towards risk does consider a risk contribution that narrows the return. This means that also the department manager needs to know and apply the decision makers risk attitude for the redesign, in order to decide in the same way as the CEO (decision maker).

2.2 Related Work

The costs/cash outflows of a process are one of the major criteria regarding decisions in BPM. This is criticized by Kanevsky and Housel (1995). They show that it is important to consider cash inflows as well. In addition, they show how the cash inflow of a process can be allocated to its components and how the value added by the components can be expressed. However, they do not consider multiple periods (R1), nor do they consider the impacts of a redesign on the value of a company including the risk contribution, as they consider the return on investment (ROI) of the process (R2). They do not account for the risk attitude of the decision maker (R3). Still, the use of both, cash outflows and inflows, and their allocation to the process components, represents an important step towards a value-based process management. Gulledge et al. (1997) state that for “the cost evaluation of […] business processes within the value-based approach, Action-Based Costing […] can be used.“ In this related work, they show that besides costs the process revenues/cash inflows are equally important. It is noted how these cash inflows might be assigned to a process. However, the authors do not consider multiple periods (R1). There is no consideration of the impacts of a process on the value of a company (R2). It is not known if the risk attitude of the decision maker is being considered or if the decision at the process level is in the best interest of the company (R3). Another work in the area of value-based process management is Neiger et al. (2006). They base the decision of which process alternative to choose on the expected value of the cash flows in one period with no consideration of multiple periods (R1). They do not connect the value contribution of a process to the value of a company (R2). In order to consider the uncertainty of the return, they perform a sensitivity analysis, but this is not included in their utility function, as this was not the primary focus of this paper. Finally, they base their decision on the expected value, implying that the decision maker is risk neutral, and therefore achieving (R3) only to a certain extent. However, they introduce the utility of process alternatives as a basis for a decision, in the special case of a risk neutral decision maker. Besides similar works of the authors, a fourth one – integrating previous research results – is vom Brocke et al. (2010). In this paper, they consider the terminal value of the investment after multiple periods (R1) and the ROI to decide which process alternative to choose. However, they focus on one process and not on the effect of that process on the value of a company (R2). They consider the expected value of each cash flow, which is used to calculate the terminal value. Just as in the previous work, implicitly, they consider a risk neutral decision maker but do not allow for risk aversion (R3). Just as the other related works, this paper increases the general knowledge in the area of value-based process management as multiple periods are considered to compare process alternatives.

3 Model for Value-Based Process Improvement

The previous section showed that existing approaches do not completely fulfill the defined requirements, which provides a research gap that we strive to close in this section. Thus we develop a basic model to perform a value-based process improvement, which simplifies certain aspects. These simplifications allow us to present the idea and a model that can be used in practice. Thus, we strive in this approach to be practical for a managerial audience, rather than complex, in order to more easily communicate it, which is an important demand of design science (Hevner et al., 2004; Peffers et al., 2008). We start by stating necessary assumptions. Afterwards, we describe how the value of a company can be calculated, representing the objective function of a company. In a next step, we will present how the value of a company is connected with the process level. There, the best process alternative can be selected by considering differences in the expected return of a process and the variance of this return, which is the risk contribution.

3.1 Assumptions

If one process r of the R processes in a company is executed, a *process instance* PI_r is triggered. A process instance is the execution of certain activities from the beginning to the end of a process. As a result of a process instance, there is a cash flow CF_{PI_r} that is caused by different kinds of certain characteristics of this process instance (e.g. cash outflow for wages, cash outflow for materials, cash inflow for selling the product, etc.). In reality, this cash flow CF_{PI_r} is uncertain (stochastic) before the process instance is executed completely, since processes often include choices (e.g. exclusive choice), which means there are different possibilities how a process can be executed. In addition, even if there is only one possibility to execute a process, the activities are most likely not executed the same way every time (e.g. activities use different amounts of material in different process instances). Therefore, CF_{PI_r} is a random variable, and so is the cash flow $CF_{P_{r_j}}$ of a process P_r in a certain period j, with $CF_{P_{r_j}} = \sum_{i=1}^{n_{r_j}} CF_{PI_{r_i}}$, where n_{r_j} is the number of process instances of process P_r in period j. In order to include multiple periods in our model (R1), we consider the (net) present value NPV_{P_r} of process P_r. It is $NPV_{P_r} = -I_{P_r} + \sum_{j=0}^{J} \frac{CF_{P_{r_j}}}{(1+w)^j}$, where I_{P_r} is an initial investment that causes a certain cash outflow (e.g. to implement or redesign a process, to analyze a process domain, etc.), $J+1$ is the number of periods and w “is the rate of interest which properly reflects the investor's time value of money.” (Hillier, 1963) This uncertain net present value of all uncertain cash flows of J future periods (fulfilling (R1)) builds the return NPV_{P_r} of a process P_r, $r=1,\dots,R$. The fact that $CF_{P_{r_j}}$ is a random variable makes the return NPV_{P_r} a random variable as well. First, we will make assumptions regarding the properties of this random variable. Before we assume that it follows a normal distribution, we describe briefly why it is plausible to make this assumption.

Normally, processes in a company are executed several times, which means there are several process instances in every period, resulting in several cash flows CF_{PI_r} per period. The sum $CF_{P_{r_j}}$ of cash flows in one period is again a random variable, which can be approximated by a random variable that is normally distributed, since the $CF_{PI_{r_i}}$ are identically distributed and we assume in the following that they are independent of each other (central limit theorem (Feller, 1968)). Hence, for each future period j, $j=0,\dots, J$, the sum of its cash flows can be represented by a normally distributed random variable. As a result, the net present value NPV_{P_r} follows a normal distribution as well (see Hillier (1963)). Accordingly, we formulate our first assumption.

(A1) *There are no kinds of dependences between the processes, i.e. between the* NPV_{P_r}, *as well as no dependences between process instances and between periods. Each return* NPV_{P_r} *is normally distributed.*

The assumption, that there are no dependences, is a simplification in this first approach that reduces the formalism significantly and eases the communication of this approach. This way, we can focus on one process and not on all processes in a company, just as in Davamanirajan et al. (2006). In addition, practical experience shows that it is difficult to measure these dependences, for example by using correlation coefficients, and it is very unlikely that the values of the correlations are known. Since NPV_{P_r} follows a normal distribution, it is fully described by its expected value and its variance, which are considered by our next assumption.

(A2) *The expected value* $E\left[NPV_{P_r}\right]$ *and the variance* $Var\left[NPV_{P_r}\right]$ *of* NPV_{P_r}, *r=1,…,R, of a process* P_r *are finite.*

We want to point out, that we do not assume to know the exact values of both the expected value and the variance of NPV_{P_r}, but that they are finite. So far, we have been at the process level. In the following, we will assume how the processes are connected with the value of a company.

The value of a company includes the net present values of all cash flows of a company, which means we must consider all of these cash flows. This could be done by separating cash flows that are caused by processes and cash flows that are caused by anything else, which would give us one random variable that represents all these other cash flows. However, for reasons of simplicity, we assume that all cash flows of a company are due to processes, i.e. the return of a company is the sum of the returns of the processes. This simplification can be assumed if a company is seen as a portfolio of processes that cause all cash flows of a company, as everything could be considered to be a process.

(A3) *The (risk-adjusted) value* Φ_C *of a company C is entirely caused by its processes* P_r, *r=1,…,R. The return of a company C is represented by the random variable* NPV_C. *It is the sum of the returns of the processes* NPV_{P_r} *of the company, i.e.* $NPV_C = \sum_{r=1}^{R} NPV_{P_r}$.

The fact that the return of a company is the sum of the returns of the processes, implies that NPV_C is the uncertain net present value of all uncertain future cash flows inside the company (R1) and that its expected value (expected return) and variance are finite. In addition, with assumption (A1) the return of a company NPV_C follows a normal distribution. With this assumption, we connected the return of a company with the return of its processes, which is essential to fulfill (R2).

We aim to decide between process alternatives based on the change of the random variable NPV_C. Therefore, it seems reasonable to use decision theory under uncertainty. In particular, we use the expected utility theory (Copeland et al., 2005). As the stakeholders should decide based on the best interest of the company/person in charge (*decision maker*) (R3), we make the following assumption regarding the decision maker, similar to Fridgen and Müller (2009) and Zimmermann et al. (2008).

(A4) *The decision maker has a constant risk aversion with respect to returns (Pratt, 1964) and maximizes the expected utility.*

As stated in Bamberg and Spremann (1981), a constant risk aversion is “flexible enough to cover a broad spectrum of risk averse patterns”, which is why we can assume the risk aversion to be constant.

3.2 Value-based Selection of Processes

Since NPV_C follows a normal distribution, it is fully described by its expected value and its variance, which means we can make a decision based on the change of these two quantities. In order to fulfill requirements (R2) and (R3), we need an objective function that combines this expected return of a company and a risk contribution (the variance), as well as the risk attitude of the decision maker and is compatible with assumption (A4). The following function fulfills the requirements and is based on expected utility theory to decide between different process alternatives:

$$\Phi_C \coloneqq \Phi(\mu_C, \sigma_C) = \mu_C - \frac{\alpha}{2}\sigma_C^2, \qquad (1)$$

where μ_C is the expected value of NPV_C, σ_C^2 is the variance and α is the risk attitude of a decision maker, the so called risk aversion constant (Freund, 1956). For a risk averse decision maker it is $\alpha > 0$ (Pratt, 1964). Although it is not an easy task to determine α, Bamberg and Spremann (1981) show how α could be determined. They show that in order to determine α, the decision maker is asked certain questions in order to elicit the risk attitude. In addition, the difficulties to choose the right questions to elicit the required information are presented.

This function was introduced by Freund (1956), and applied in more recent works such as Fridgen and Müller (2009), Longley-Cook (1998) and Zimmermann et al. (2008). According to Freund (1956), function (1) can be used, if the decision maker has a utility function of the form $u(x) = 1 - e^{-\alpha \cdot x}$ and if NPV_C is normally distributed. This is due to the fact that if function (1) is maximized, the expected utility $E[u(NPV_C)] = 1 - e^{-\alpha \cdot (\mu_C - 0.5 \cdot \alpha \cdot \sigma_C^2)}$ is maximized. As we assume the decision maker to have a constant risk aversion (A4), the decision maker has indeed an exponential utility function (Bamberg and Spremann, 1981). Such exponential utility function can be $u(x)$, which is also similar to empirically found utility functions by Swalm (1966). Furthermore, since NPV_C is normally distributed, Φ_C is the certainty equivalent $u^{-1}(E[u(NPV_C)])$ (Copeland et al., 2005) of the normal distributed return of a company with constant risk aversion and can therefore be seen as the (risk-adjusted) value of a company (Bamberg et al., 2006).

We will show that in order to know which process alternative increases Φ_C the most, we do not need to know the value of μ_C and σ_C^2. It is enough to know how much the expected value and the variance of the return of the process, which is to be redesigned, change through the redesign, making the model more efficient. For a formal way to show this, we will introduce some additional notations.

Let, without loss of generality, P_R be the process that a company C might want to redesign. Further, let P_R' be any process alternative of P_R and Φ_C' the new value of C, if the modifications in P_R' would be implemented, i.e if P_R' would be selected as the alternative to P_R. Then let be

- $NPV_C = \sum_{r=1}^{R} NPV_{P_r}$ the return of C without redesign, with $\mu_{P_R} := E\left[NPV_{P_R}\right]$ and $\sigma_{P_R}^2 \coloneqq Var\left[NPV_{P_R}\right]$,
- $NPV_C' := \sum_{r=1}^{R-1} NPV_{P_r} + NPV_{P_R'}$ the return of C if P_R would be redesigned to P_R', with $\mu_{P_R'} := E\left[NPV_{P_R'}\right]$ and $\sigma_{P_R'}^2 \coloneqq Var\left[NPV_{P_R'}\right]$,
- $\Phi_C := \Phi(\mu_C, \sigma_C) = \mu_C - \frac{\alpha}{2}\sigma_C^2 = E[NPV_C] - \frac{\alpha}{2}Var[NPV_C]$ the value of C without redesign,
- $\Phi_C' := \Phi(\mu_C', \sigma_C') = \mu_C' - \frac{\alpha}{2}{\sigma_C'}^2 = E[NPV_C'] - \frac{\alpha}{2}Var[NPV_C']$ the value of C if P_R would be redesigned to P_R',
- $\Delta\Phi_C' := \Phi_C' - \Phi_C$ the difference in the values of C if P_R would be redesigned to P_R', and
- $\Delta\mu_{P_R'} \coloneqq \mu_{P_R'} - \mu_{P_R}$ and $\Delta\sigma_{P_R'}^2 \coloneqq \sigma_{P_R'}^2 - \sigma_{P_R}^2$ the differences between the existing process and any process alternative P_R' in terms of the expected return and the variance of the return, respectively.

With this, it can be formally shown that

$$\Delta\Phi_C' = \Delta\mu_{P_R'} - \frac{\alpha}{2}\Delta\sigma_{P_R'}^2. \qquad (2)$$

If $\Delta\mu_{P_R'}$ and $\Delta\sigma_{P_R'}^2$ can be determined for all process alternatives of P_R, then we can select the best alternative in the interest of the company at the process level (R3) by calculating $\Delta\Phi_C'$. Therefore we extend the assumption (A2) to the following assumption (A2)'.

(A2)' *Assumption (A2) holds. In addition, although the expected value and variance of* NPV_{P_R} *and* $NPV_{P_R'}$ *are not known, the differences* $\Delta\mu_{P_R'}$ *and* $\Delta\sigma^2_{P_R'}$ *can be determined. This is true for every process alternative* P_R'.

Therefore, if we know how much the return of a process changes, in terms of its expected value and its variance, we can calculate how much the change of this process return NPV_{P_R} – ceteris paribus – changes the value of the company, connecting the process level with the value of the company. Thus, the stakeholders at the process level can decide at that level in the best interest of the company, using the same risk attitude as the decision maker and not their own attitude towards risk (R3). In the end, we select the process alternative with the highest $\Delta\Phi_C'$ to realize a value-based process improvement. Of course, if $\Delta\Phi_C'$ is negative for all process alternatives, there would be no redesign unless a redesign is necessary, for example due to new regulations. Equation (2) presents the heart of our approach (our artifact) for a value-based process management.

In addition, we can also select between newly designed processes P_R', and not just redesigns, in the special case of the quantities $\mu_{P_R'}$ and $\sigma^2_{P_R'}$ being known, and setting $\mu_{P_R} = 0$ and $\sigma^2_{P_R} = 0$, using equation (2). Furthermore, with the function $\Phi_{P_r} \coloneqq \Phi\left(\mu_{P_r}, \sigma_{P_r}\right) = \mu_{P_r} - \frac{\alpha}{2}\sigma^2_{P_r}$, we can obtain the stand-alone value contribution of a process P_r to the value of a company.

4 Application

In Neiger et al. (2006), a scenario is given and four alternatives (including the existing process) for a process are presented. We will use our approach to select an alternative. The scenario is given as:

“In June 2005, the payroll process of a large educational institution failed. More than 4,000 employees were not paid on schedule, but on the following day instead. This unanticipated delay resulted in bounced checks, rejected automatic bill payments and declined check card purchases by staff and faculty, who did not receive information about this delay in time. A hastily installed mediation procedure allowed employees to receive their compensation as a cash payout, which was then deducted from their following month’s paycheck, depleting cash reserves of the university.

An investigation of the problem revealed that the cause for the delay was a data entry mistake made by a staff member who entered the wrong payroll date in one step of the payroll process. Two administrators signed off on the scheduled payroll run and did not notice the wrong date. The payroll run order was transmitted to the university’s bank for processing and when the error was discovered it was too late to re-schedule the payroll run.”

We do not know the whole payroll process P_r, which means we cannot determine Φ_{P_r}. However, as equation (2) states, this is not necessary, as it is enough to know the effects of the possible redesigns, which result in different $\Delta\Phi_C'$. The existing, and to be changed, sub-process of the payroll process, can be represented by a sequential process *SP*. The existing process *SP* has one activity “Enter Payroll run information”, with a cash outflow of $1,000 per process instance, and two separate activities “Approve Payroll run”, with each having a cash outflow of $500 per process instance. In case the process *SP* goes wrong, the rectification costs are $250,000. In addition to the existing process *SP*, they give three process alternatives. All four alternatives have a probability that a problem occurs (*failure probability*), that could result in the cash outflow of $250,000. The alternatives are:

- *Alternative 1*: One entry activity and one approval activity; failure probability: 1.5%.
- *Alternative 2*: Two separate entry activities, where two different persons enter the same data, and one approval activity; failure probability: 0.075%.
- *Alternative 3* (existing process): One entry activity and two separate approval activities, where two different administrators have to approve the data; failure probability: 0.45%.
- *Alternative 4*: Two separate entry activities and two separate approval activities; failure probability: 0.0225%.

We state some assumptions that are not explicitly made in Neiger et al. (2006), but are implicit to some extent, and need to be made to use our approach, before we present $\Delta\Phi'_C$ for each alternative. In Neiger et al. (2006), the alternatives are compared on the basis of the expected cash flow per process instance for each alternative. This is only valid, if the number $n_{r\,j}$ of process instances, which are executed in each period, is the same for each alternative, i.e. the redesign does not have any effect on the number of process instances. For each activity “Enter Payroll run information” is $E[CF_{enter}] = -1{,}000$ and $Var[CF_{enter}] = 0$ and for each activity “Approve Payroll run” is $E\left[CF_{approve}\right] = -500$ and $Var\left[CF_{approve}\right] = 0$ for every process instance. When modeling the four alternatives it is easy to add this information of the cash flows CF_{enter} and $CF_{approve}$ to the activities, just as the rectification costs to the process, and simulate the alternatives to determine a sample mean and sample variance of CF_{SP_j} for this sub-process. Since such a payroll process exists in many educational institutions and companies, the number of simulated process instances is set to $n_{r\,j} = 25{,}000$. Only one period is considered in Neiger et al. (2006) and there are no cash outflows to change the existing process. Thus, for the sake of simplicity and to be comparable with Neiger et al. (2006), we set $J=0$ and $I_{SP}=0$. A comparison with $J>0$ would be easily possible with the NPV. However, in this scenario it would lead to the same result, as $n_{r\,j}$ is the same for each alternative. This means, CF_{SP_0} of the sub-process can be determined and it is $CF_{SP_0} = NPV_{SP}$ of the sub-process. In terms of the whole process, we assume that the whole payroll process P_r can be represented as a sequential process, with all activities having a variance of zero, just as it is with the activities “Enter Payroll run information” and “Approve Payroll run”. The rectification costs represent all cash outflows if something goes wrong with P_r. With this, and since $n_{r\,j}$ is fairly high, it can be assumed that the return NPV_{P_r} of the process P_r as well as the return NPV_{SP} of the sub-process SP follow a normal distribution (A1), where $E[NPV_{SP}]$ is set to the sample mean of CF_{SP_j} and $Var[NPV_{SP}]$ is set to the sample variance of CF_{SP_j} (law of large numbers) (A2). As nothing differently is stated in Neiger et al. (2006), we can assume that there are no kinds of dependences (A1). Further, we assume that (A3) and (A4) hold as well and the risk aversion of the decision maker is assumed to be $\alpha=0.0001$.

With this, we can determine $\Delta\Phi'_C$ for each alternative via several simulation runs of SP. The model to determine $\Delta\Phi'_C$ can easily be implemented into a process modeling tool. The result is presented in table 1. It is P_R the existing payroll process (alternative 3), P'_R represents the alternatives.

Alternative	$\Delta\mu_{P'_R}$	$\Delta\sigma^2_{P'_R}$	$\Delta\Phi'_C$
1	$-53.1 \cdot 10^6$	$16.1 \cdot 10^{12}$	$-8.6 \cdot 10^8$
2	$10.9 \cdot 10^6$	$-5.8 \cdot 10^{12}$	$3.0 \cdot 10^8$
3	0.00	0.00	0.00
4	$1.7 \cdot 10^6$	$-6.7 \cdot 10^{12}$	$3.3 \cdot 10^8$

Table 1. Changes of the Value Contribution of the Payroll process with different redesigns

Of course, alternative 3 has $\Delta\Phi'_C = 0$, because it is the existing process. With the presented approach we select the alternative with the highest $\Delta\Phi'_C$ which results in the decision to use alternative 4.

5 Evaluation

First, we analyze to what extend we achieve our aim and how far we close the research gap, which is identified in section 2. Then we compare our approach with the model used in Neiger et al. (2006).

5.1 Closing the Research Gap

In subsection 2.1, we state three requirements for an approach to enable a value-based process management, providing the objectives for such an approach. We concluded, that there are works that already satisfy (R1) and (R3) to a certain extent. With our approach, we can consider multiple periods as we use net present values (R1). We present an appropriate objective function for a company with equation (1), fulfilling requirement (R2). With equation (2) we provide a way to make decisions at the process level in the best interest of the company (R3). Thus, we closed the research gap and developed a complete and effective artifact (Hevner et al., 2004).

5.2 Comparison with Competing Artifact

Hevner et al. (2004) stressed that an artifact must be evaluated with respect to the practical utility provided. We presented the practical utility in the application, as we used it in a real world scenario. We used our approach to select a process alternative and will now examine the result in comparison to Neiger et al. (2006). Their recommendation is to choose alternative 2. Our approach results in the same recommendation in the special case of a risk neutral decision maker ($\alpha=0$). However, if we consider the decision maker to be risk averse (with $\alpha=0.0001$), we recommend to use alternative 4, although $\Delta\mu_{P_R'}$ is higher for alternative 2 and α is close to zero. It is the same result when taking the sensitivity analysis in Neiger et al. (2006) into account. This is due to the lowest failure probability in alternative 4, lowering the variance of CF_{SP_0} of that alternative, and the risk attitude of the decision maker. This demonstrates how important it is to consider the risk aversion of a decision maker and the deviation of the return, which is possible with our approach. We can show this importance even more, if we do not set $Var[CF_{enter}] = 0$ and $Var[CF_{approve}] = 0$, as it is done in table 2.

	$\sqrt{Var[CF_{approve}]}$	0	50	100	200	300	400
$\sqrt{Var[CF_{enter}]}$	0	Alt. 4	Alt. 2	Alt. 2	Alt. 2	Alt. 2	Alt. 2
	50	Alt. 4	Alt. 2	Alt. 2	Alt. 2	Alt. 2	Alt. 2
	100	Alt. 4	Alt. 2	Alt. 2	Alt. 2	Alt. 2	Alt. 2
	200	Alt. 3	Alt. 3	Alt. 3	Alt. 1	Alt. 1	Alt. 1
	300	Alt. 3	Alt. 3	Alt. 3	Alt. 1	Alt. 1	Alt. 1
	400	Alt. 3	Alt. 3	Alt. 3	Alt. 1	Alt. 1	Alt. 1

Table 2. Resulting Alternative with different Standard Deviations of the Activities' Cash Flows

In table 2 it can be seen that if the deviations of the activity cash flow are small, then the rectification costs are the major risks to be considered, which is why it is reasonable to use more activities to look for mistakes. However, as the deviations of the activity cash flow increase, it is better to use fewer activities to lower the risk of deviations and take a higher risk that an error occurs. This demonstrates how important it is to consider deviations from expected values and not only the expected values. It shows the advantage of our approach as compared to a model that decides solely on the basis of expected values. Neiger et al. (2006) do a sensitivity analysis to account for the risk that these returns may vary, but such variation is not part of the function to decide for a process alternative.

It can be noticed, that we talk about the deviation from the expected value as a risk. However, Neiger et al. (2006) consider the risk that data is entered wrongly and the mistake is not discovered. There seems to be a different understanding of risk, which makes it questionable as to whether the two approaches can be compared. According to Hansson (2005) there is not only one single meaning of risk. The author also states that "at present, by far the most common technical definition of risk" is "risk as statistical expectation value of unwanted events, which may or may not occur." In this *first definition*, risk is seen as probability multiplied by the consequence of an unwanted event, which is an expected loss. These kinds of risks are part of the expected return. This means, they are included in both approaches. However, since we want to provide a value-based approach, we have to consider the meaning of risk from a finance perspective. In finance, risk "refers to the likelihood that we will receive a return on an investment that is different from the return we expect to make." (Damodaran, 2002) This *second definition* sees risk as difference from an expected return and therefore considers good and bad unwanted events. With our approach, the expected loss is part of the expected return, and the variation of this loss/cash outflow is part of the risk contribution. Therefore, our approach can handle this kind of risk (second definition) as well, extending the model used in Neiger et al. (2006).

6 Conclusion

In this paper, we describe how to perform the improvement of processes in an *effective* and *efficient* manner. It is effective, since it directly targets the value of a company which is the main focus of managers, and it is efficient, since only $\Delta\Phi_C'$ is necessary, but not Φ_C' as a whole. Related to the guidelines for conducting design science research by Hevner et al. (2004), we can summarize as follows: Our *artifact* is an approach to support decisions on how to improve a process with the goal of increasing the value of a company. We regard this as an important step to improve processes from a business view during a process (re-)design. The model is formally noted and can thus be evaluated. This builds the basis to use the common evaluation criteria of process improvements like time, costs, customer satisfaction, output quality, etc. Those criteria need to be specified on process level and transformed into monetary values, so that their return and risk contribution can be determined. A detailed analysis of how to incorporate these criteria should be addressed in further research.

Our artifact is thought to contribute to process management, to design and adapt processes in the interest of a company and to be useful regarding decisions at the process level. Since such a statement cannot hold for every process, the question of when to apply a model to perform a value-based process improvement needs to be clarified. Such a clarification is required to specify the boundaries within which the model is expected to be applied. The amount of information that is needed could put a limitation to the processes. In order to get the information, there are initial costs to analyze the problem domain. If this information can later be reused during further (re-)design projects, then the costs to retrieve the information might be worthwhile. This might limit the approach to processes that are redesigned more often. However, since BPM is an ongoing task inside a company and the risks of processes can be quite considerable, we assume that it is worthwhile in many cases, to gather the information. Another limitation is the assumption of normal distribution. This assumption holds for instance, due to the central limit theorem, if there are no dependences and if processes are executed several times, which limits the approach for example to highly repetitive processes.

Further work is proposed on the question of how dependences can be considered, as it might have a big impact on the selection of the right process alternative. Other work is necessary if the number of process alternatives that need to be compared is very high. For efficiency reasons, this task should be automated. Thus, we would need the corresponding process models that are extended with financial values. With these process models, combined with the use of our or similar approaches to select process alternatives on the basis of financial values, the selection could be automated. This would also allow the valuation of complex processes, where the gathering of the required amount of information limits the applicability of our approach. For this future work, the designed model is a reliable basis for value-based process improvement, to support the CIO to meet the primary business priority of IT.

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