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Valuation of manual and automated process redesign from a business perspective

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Abstract

Purpose – The continuous redesign of processes is crucial for companies in times of tough competition and fast-changing surrounding conditions. Since the manual redesign of processes is a time- and resource-consuming task, automated redesign will increasingly become a useful alternative. Hence, future redesign projects need to be valuated based on both a manual and an automated redesign approach. The purpose of this paper is to compare the manual and automated process redesign on the basis of the Business Process Management (BPM) lifecycle.

Design/methodology/approach – In this paper, the authors compare the manual and automated process redesign on the basis of the Business Process Management (BPM) lifecycle. The results form the basis for a mathematical model that outlines the general economic characteristics of process redesign as well as for the manual and automated approaches. Subsequently, the authors exemplarily apply their model to a set of empirical data with respective assumptions on particular aspects of the automated approach.

Findings – In the problem setting described in the paper, the valuation model shows that automated process redesign induces an equal or higher number of optimized processes in a company. Therefore, the authors present a decision support that outlines how much to invest in automated process redesign.

Research limitations/implications – The model considers the cost side of automated process redesign; therefore, further research should be conducted to analyze the possibility of higher returns induced by automated redesign (e.g., through a quicker adaption to real-world changes). Moreover, for automated redesign, there is no requirement for broad empirical data that should be collected and analyzed as soon as this approach leaves the basic research and prototyping stages.

Practical implications – This paper presents an approach that can be used by companies to estimate the upper limit for investments in manual and automated process redesign. Working under certain general assumptions and independently from actual cost and return values, the paper demonstrates that automated process redesign induces an equal or higher ratio of optimized processes. Thus, companies introducing automated redesign cannot only apply the model to evaluate their investments but can also expect a higher ratio of optimized processes for this approach.

Originality/value – As existing literature primarily focuses on the technical aspects of automated process redesign, these findings contribute to the current body of literature. This paper discusses a first decision-support for the economic aspects of automated process redesign, particularly with regard to the investments that are required for it. This information is relevant as soon as the approach leaves the stage of a prototype.

Keywords Semantic business process management, Automated process redesign, Business process modeling, Optimization model, Business process management, Process planning

Paper type Research paper

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1. Introduction

Business process management (BPM) has become a powerful instrument for fighting a company's lack of capability to adapt to changing customer needs, legal requirements, and other surrounding conditions, and is thereby essential for a company's organizational design (Buhl *et al.*, 2011; Gartner, 2010; Sidorova and Isik, 2010; Trkman, 2010; vom Brocke *et al.*, 2011). Although BPM has supported the redesign of business processes since the early 1990s, there is scope for improvement, especially in association with modern IT systems, which are considered critical success factors in business process reengineering (Ahmad *et al.*, 2007).

This lack of automation can be observed in typical redesign projects. The redesign is usually performed by analysts and managers who have in-depth knowledge in their respective domains. Due to its high human involvement, we call this approach manual process redesign. Because of the increasing complexity of today's processes, manual process redesign is very time and resource consuming. Thus, processes are redesigned rarely, with high expenses, or not at all. This results in an increased time to market and high costs resulting from suboptimal processes. To deal with these shortcomings, researchers have sought alternatives to manual redesign. Recent research elaborates on how process redesign can be automated and supported by IT. New approaches addressing this issue (Betz *et al.*, 2006; Brockmans *et al.*, 2006; Hepp and Dumitri, 2007; Heinrich *et al.*, 2008) are situated in the field of semantic business process management (SBPM) and are based on the vision of Hepp *et al.* (2005). Among other aspects, SBPM includes the semantic annotation of process actions as components of a business process in order to enable semantic-based reasoning for the automated creation, adaption, and redesign of business processes. We call this approach automated process redesign. Due to high automation, automated redesign can offer a faster and cheaper development of process models than its manual counterpart. However, the semantic annotation of process actions as well as the technical integration of the related planning software in a company's IT architecture can result in high expenses.

This trade-off between high setup costs and improvements in the redesign approach leads to the following question: under which economic circumstances are extensive investments in automated process planning justified? The need for an answer to this question is reinforced by the fact that research in the field of automated process redesign has advanced and the first applications that are a result of these advances are becoming more feasible. For example, process verification, a method closely related to automated process modeling, "has matured to a level where it can be used in practice" (Wynn *et al.*, 2009).

We, therefore, present a quantitative model that derives an upper limit for investments in automated process planning and show that it is superior to manual process planning. As a necessary base for this decision, we evaluate the basic characteristics of process redesign projects (PRPs) and also study the factors that influence the optimal selection of these projects.

Consequently, we put forth the following research questions:

RQ1. Which and how many PRPs should be realized based on their respective costs, returns, and project sizes?

RQ2. What is the upper limit for investments in automated redesign so that it is superior to manual redesign from a business perspective?

As already mentioned, the answer to *RQ1* forms the basis for *RQ2*, since the optimal selection of PRPs gives different results for each approach. This selection is represented in our objective functions, which are the contribution margin functions of the two alternatives. The functions are subject to the execution of redesign projects, specifically to their exogenously given return and cost parameters, as well as to given redesign project sizes. Our decision variable is a ratio of the processes to be redesigned that influences the attainable yield. After making an optimal selection of PRPs that will lead to an achievable monetary contribution margin, we compare the utility (represented by the yield) of both manual and automated redesign to identify an upper limit for investments in automated redesign.

We are aware that the semantic annotation necessary for automated process redesign opens up further opportunities for higher returns for companies that invest in process management. Nevertheless, in this paper, we focus on the cost side of process redesign, since the possible cost reduction of automated process redesign should encourage companies to adopt an automated redesign approach. Moreover, the return on investment in the short run would be the main evaluation criterion for a company. Therefore, this contribution serves as the first step for companies to improve their process redesign approach or change it to a more adequate one as soon as the automated process redesign leaves the stage of prototyping.

In Section 2, we elaborate on the literature. In Section 3, we state the general characteristics of process redesign, introduce automated process redesign, and compare this approach with its manual counterpart. Based on these findings, we present an optimization model in Section 4. In Section 5, we illustrate the practical applications of the model on the basis of empirical data on a large German financial services provider. In the last section, we summarize the results and point out areas for future research.

2. Related work

The redesign of business processes is based on the presence of flexible processes and the flexible creation of process models. Process flexibility can be classified according to three criteria: the abstraction level of change (where does change occur?), the subject of change (what has changed?), and the properties of change (how are things changing?) (Regev *et al.*, 2005). The field of automated process redesign is related to the enhancement of flexibility in business processes. The flexible creation of process models according to real-world changes helps to rapidly identify the subject of change. In particular, the executed activities and the related preconditions for these can be identified and documented quickly by comparing the process models before and after the real-world change. However, in our paper, we do not focus on the process flexibility resulting from automated redesign. We concentrate on the economic aspect of process redesign and show the differences between automated and manual process redesign.

The need for the flexible creation and adoption of process models typically represents a bottleneck for numerous companies (Becker and Kahn, 2003; van der Aalst *et al.*, 2006). The high human involvement which necessitates greater effort during manual process redesign is exemplified by Harrington (1991), who suggests that the manager or process expert who is in charge of the process redesign should be physically present in the division in which the business process to be redesigned is situated, and observe the procedures in detail.

New approaches toward process modeling, such as those detailed by Betz *et al.* (2006), Brockmans *et al.* (2006) and Hepp (2007) are employed in the field of SBPM and are based on the vision of Hepp *et al.* (2005). Heinrich *et al.* (2008) and Eisenbarth *et al.* (2011) specifically propose a semantic approach that uses ontologies as the basis of an algorithm for automated process redesign.

Current research does not consider the economic aspects of SBPM. However, a fundamental analysis is claimed several times (Haniewicz *et al.*, 2008; Hepp, 2007). Thus, the need for a valuation model for automated redesign arises as soon as the research leaves the theoretical state and advances to prototypes, since the creation of ontologies and the semantic annotation of process actions involve, among others, high implementation costs (Heinrich *et al.*, 2008; Kuropka and Weske, 2008).

The field of automated process redesign is closely related to the field of automated web service composition. Héam *et al.* (2007) present an approach to semantically specify different types of service costs for a web service, such as monetary costs and execution time. This annotation is an aspect of service quality and is further used to economically facilitate the automated composition of web services. In contrast, we take the costs of PRPs as given. Additionally, we outline a model that provides details on how to use these costs and predicted returns, and select PRPs that are economically feasible. Finally, we present a key figure that supports the decision for a proper redesign approach.

ONTOCOM, the cost model for ontology engineering, was presented by Simperl *et al.* (2006). ONTOCOM predicts the costs arising from the creation of an ontology that follows a particular ontology development strategy. Analogous to COCOMO (constructive cost model) (Boehm, 1981), ONTOCOM features a variety of cost drivers that influence the costs related to the activities that helped create the ontologies. Although ONTOCOM could help estimate the cost of an ontology – and this ontology is required for automated process redesign – our paper does not focus on the creation of ontologies.

When creating ontologies, other factors besides the economic aspect need to be considered. Hepp (2007) points out four obstacles to the use of semantic concepts such as ontologies: conceptual dynamics (new elements arise while other elements become irrelevant), economic incentives (the creation and use of the semantic concepts have to be economically reasonable), ontology perspicuity (the ontology should be interpretable by its users), and intellectual property rights (since industrial standards are often protected by intellectual property rights, legal agreements with the owners of ontologized industrial standards are necessary). These four obstacles can be examined from the perspective of automated process redesign. The main part of our paper is dedicated to detailing the economic advantages of using the automated redesign approach. The perspicuity of the automatically generated process models is adequate, since the resulting process models are represented in acknowledged modeling languages such as UML-activity diagrams. Issues regarding intellectual property rights are dealt with by the payment of a certain acquisition price, which we attribute to automated process redesign software and the associated ontologies. The obstacles of conceptual dynamics, however, are real-world changes and are not directly addressed in our paper. This will, however, be subject to further research.

3. Characteristics of process redesign

To adapt, for example, to changing customer needs or legal requirements, multiple processes need to be redesigned from time to time. Usually, this is accomplished by PRPs. Each PRP can be conducted only once, is targeted at redesigning an existing business process, and features a certain project size. Furthermore, we assume that a PRP can only be conducted completely or not at all. For simplicity, we focus on redesigning already documented and modeled processes in this paper. However, the model may be adapted to include the modeling of new processes in future research. We state the general characteristics of automated process redesign in Subsection 3.1 and compare this approach with manual redesign in Subsection 3.2.

3.1 Automated process redesign

Automated process redesign is a relatively new way of redesigning processes. It is based on the semantic definition of the possible process steps (actions) that are automatically arranged in a control flow, and lead from an initial state to the desired final state. The redesign is no longer performed by human beings, but by an algorithm that uses semantic concepts and automated reasoning to create process models, which eventually have to be controlled by experts.

Some approaches in SBPM suggest a comprehensive conceptualization of all the model and meta-model elements of the process model in order to include a wide range of goals, such as a test for the correctness of models (Thomas and Fellmann, 2007). Others choose a less restrictive approach for the annotation of process actions, which is similar to the semantic annotation of semantic web service composition, and aims specifically at the redesign of business processes (Heinrich *et al.*, 2008).

Before automated redesign can be used, certain requirements have to be fulfilled. First, the redesign software (e.g. the SEMPA tool, cf. Heinrich *et al.* (2008)) is to be purchased and installed in the IT system of the company. The next step for the company is to analyze its environment, that is, to identify all relevant concepts that need to be annotated semantically (e.g. a customer's financial data), their relationships, and the necessary process actions. The identified concepts in the specific domain of interest as well as their relationship have to be represented in an ontology. This ontology either has to be created from scratch or can be an existing (public) ontology (e.g. the COBrA ontology proposed by Pedrinaci *et al.* (2008)). Using a public ontology involves costs for search, application, analysis, and customization. For a deeper analysis of the costs of ontology engineering, refer to Simperl *et al.* (2006). The previously identified process actions have to be semantically annotated by their input and output parameters (by means of ontological concepts) and filed into a process library, a repository of the redesign software that contains the process actions used during automated modeling. It must be noted that we consider the expressiveness of the semantic annotation as fixed; that is, we do not distinguish between different forms of semantic annotations.

As soon as the requirements for the automated process redesign are given, the planning problems for each process redesign have to be defined before planning can begin. A planning problem consists of initial and final states. The initial state represents the starting point of a process, whereas the goals represent the desired results of it. The outcome includes the graphical representation of the redesigned process as a process model, which is comparable to that in manual process redesign.

3.2 Comparison of manual and automated process redesign

According to Karastoyanova *et al.* (2008), the SBPM lifecycle includes the modeling, analysis, configuration, and execution phases. Process redesign includes the analysis and modeling phases, while configuration and execution are directly affected by the output of the redesign, that is, the redesigned process models.

The setup establishes the necessary base for the application of the redesign approach, and needs to be executed only once. The initial steps, such as acquiring the required software and hardware for redesign, training the redesign personnel, and purchasing licenses, are to be completed. Manual process redesign requires investments in the department charged with the redesign, as well as expenses for nonautomated modeling tools. For automated redesign, the setup is much more complex. As mentioned previously, the actual automated redesign software has to be acquired, an ontology with a general base of multiple purpose concepts likely to be present in a large number of processes has to be created or customized, and the process library has to be established.

In analysis, the potential for redesign is explored. Specific processes concerning modified conditions, such as new legal requirements, a changed business model, novel customer needs, and technological innovations, are analyzed. With a manual approach, analysis includes activities to be completed by managers or process experts, such as understanding the workflow and the surrounding conditions of the process, defining the desired goals, identifying the specific actions involved in the current process workflow, and determining how these actions are interrelated. The automated approach, on the other hand, does not require an in-depth understanding of the specific workflow of the processes. In either case, it is necessary to identify the current state of processes as well as the desired goals in order to define the planning problems. Additionally, the ontology and the process library are extended with further concepts and necessary actions.

Modeling refers to the actual revision of processes; that is, the processes are adjusted based on the need for change, which is determined in the analysis phase. The best fitting process steps are selected, the appropriate organizational sections are specified, and finally, the control flow is arranged with the aid of control flow structures. The process steps may be selected on the basis of speed, quality of service, cost (Hammer and Champy, 1995), the financial aspects on the operational level (Vom Brocke *et al.*, 2010), or the process value (Bolsinger *et al.*, 2011). The results are graphically represented in process models such as UML-activity diagrams (OMG, 2008) and event driven process chains (Keller *et al.*, 1992). For manual redesign, the modeling is performed by human beings who reassess the workflow of the process. The process expert has to answer questions such as "which actions can be realized in parallel?" "which dependencies exist between multiple process actions?" and "which possible orders of process actions lead to the desired final states?". Automated redesign also involves these tasks, but unlike manual redesign, they are performed automatically. In the modeling phase of automated process redesign, human interaction is required only for the input of the previously defined initial and final states, and for a revision of the generated process models.

The effects of process redesign can be identified during the last two phases of the SBPM lifecycle. The completed process models are rolled out during the configuration phase. More precisely, concrete resources are assigned to the corresponding process steps and the process models are operationalized and implemented. The necessary changes in the company's organizational structure and IT infrastructure are also made. If all preceding phases have been successfully executed, the redesigned processes can proceed to the execution phase. During this phase, the processes can be executed as planned, and they generate cash flows over multiple executions. Both redesign methods result in qualitatively equal process models, which have to be operationalized and implemented in the same way. As a result, the execution of the redesigned processes is analogous. Automated process redesign has more advantages, such as the representation of the various feasible solutions to the problem, and the possibility of the usage of semantic annotations for controlling the process. However, in this paper, we concentrate on the cost side of this approach, leaving the exploration of its other advantages to future research.

To sum up, we can state that in the setup phase automated redesign causes much higher setup costs due to the high cost of software, ontologies, and process libraries. The setup costs for manual process redesign are the expenses for training personnel on process modeling and the license costs for nonautomated process modeling tools. We can conclude that automated process redesign involves lower costs for the redesign of one process than manual process redesign, especially considering the amount saved due to automatization in the phases of analysis and modeling.

4. Model

From an economic point of view, investments in process redesign should only be made if the resulting contribution margin of the redesign exceeds these investments. Thus, the contribution margin of the redesign serves as an upper limit for investments in this area. Consequently, the maximum contribution margin of process redesign and thus the optimal number of PRPs have to be determined, since redesigning all possible processes is not considered reasonable from an economic point of view. Therefore, a PRP aims at the redesign of a single process. To provide a mathematical foundation for the selection of PRPs, we introduce the ratio of redesigned processes (RORP) as a continuous variable and then match the selection of PRPs to this measure. To calculate the optimal RORP, we need to evaluate the returns of a PRP (the change in cash flow resulting from the execution of a redesigned process) and compare these values with the respective costs of the PRP (the costs of redesign). We introduce a general optimization model for process redesign in Subsection 4.1 and extend this model in Subsection 4.2, for a comparison of manual and automated process redesign.

4.1 Valuation of process redesign

In this subsection, we present our economic model in a general form. The following definitions and assumptions form the basis for the subsequent optimization model. Assumption 1 presents the exogenously given parameters of the model.

Assumption 1. A PRP is characterized by returns (the discounted additional returns from the execution of a PRP), costs (the discounted redesign costs of this process), and size (the project size of the PRP), which are *ex ante* predictable for a defined forecasting horizon, and thus exogenously given.

The project size (e.g. measured in person days) for a PRP serves as a measure of the complexity of the process redesign. The more complex the redesign, the higher will be the project size.

Definition. The continuous[1] variable to be optimized is the RORP, indicated by x. It is the ratio between the cumulated project size of the PRPs to be conducted and the cumulated project size of all possible PRPs.

A RORP of $x = 0$ implies that no PRP is performed, while $x = 1$ implies that every PRP is accomplished. $x = 0.5$ indicates that 50 percent of all cumulated project sizes should be spent for the most profitable PRPs.

To determine its "profitability", we analyze each PRP with respect to its resulting returns, redesign costs, and project size. We then derive the influence of each PRP on the cumulated returns and rank their marginal effect with respect to the project size. In other words, we sort all projects in descending order by the ratio "returns/project size". Cumulating the sorted returns and costs of each PRP leads to return and cost functions, $R(x)$ and $C(x)$, which represent the returns and costs of all possible PRPs, sorted by descending profitability.

With an increasing x, the previous sorting causes monotonically increasing returns. The increasing form of the function is realistic because a higher number of PRPs lead to higher cumulated returns. Further, a diminishing marginal return is directly associated with the sorting, in descending order, of the ratio "returns/project size" for all PRPs. To simplify calculations, we make the following Assumption 2.

Assumption 2. The cumulative return function $R(x)$ is a positive, continuous function that is continuously differentiable twice, monotonically increasing $(dR(x)/dx) \geq 0$, and concave $((d)^2 R(x)/dx^2) \leq 0$.

The cumulative cost function of process redesign is a strictly monotonically increasing function. Analogous to the returns of the redesigned projects, the redesign costs are cumulated and then sorted according to an increasing RORP. Further, the cost function is linear, since the redesign cost of a PRP is a result of the project size multiplied by a given cost unit rate. The cost unit rate, and thus, the gradient of the cost function, is assumed equal for every PRP.

Assumption 3. The cumulative cost function $C(x)$, is a positive, linear function that is strictly monotonically increasing $(dc(x)/dx) > 0$, and features setup costs $s \geq 0$. The variable cost function $\hat{C}(x)$ does not include setup costs; that is, $C(x) = \hat{C}(x) + S$.

Figure 1 visualizes the general optimization setting.

We now consider the variable cost function $\hat{C}(x)$. The contribution margin $\hat{Y}(x)$, is used in the second step of the calculation of the upper limit of the setup costs of process redesign S^{max}.

The contribution margin $\hat{Y}(x)$, depends on the optimal RORP x. It is determined by calculating the difference between the returns $R(x)$ of the completed process redesigns and the variable costs $\hat{C}(x)$ induced by the redesign projects:

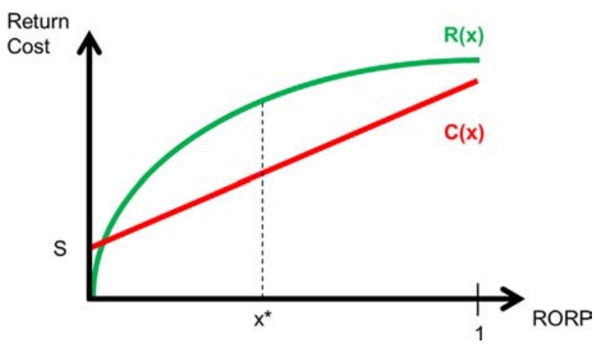

Figure 1.
General optimization setting

$$\hat{Y}(x) = R(x) - \hat{C}(x) \rightarrow max! \quad (1)$$

The company strives to maximize its contribution margin and seeks to arrive at the optimal RORP to achieve this, which we denote by $\hat{x}$[2].

To derive the actual optimum x^* in [0; 1], the position of $\hat{x}$ has to be analyzed:

$$\text{For } \hat{x} \in [0;1]: \quad x^* = \hat{x} \quad (2)$$

$$\text{For } \hat{x} > 1: \quad x^* = 1 \quad (3)$$

$$\text{For } \hat{x} < 0: \quad x^* = 0 \quad (4)$$

Additionally, there is no process redesign to be applied ($x^* = 0$) for a negative contribution margin $\hat{Y}(\hat{x})$. To ensure a positive yield $\hat{Y}(X^*)$, the contribution margin of the redesign projects $\hat{Y}(X^*)$ has to exceed the setup costs S. Therefore, the upper limit for the setup costs is:

$$S^{max} = \hat{Y}(X^*). \quad (5)$$

Based on this general optimization, we now compare manual and automated process redesign and derive a decision support on how much to spend for manual or automated process redesign.

4.2 Comparison of manual and automated process redesign

We determine the suitable cost functions depending on the RORP for both manual and automated redesign. According to Assumption 2, there exists only one return function for both the redesign approaches. In our notation of the model parameters, we use the lower indices of M and A for manual and automated redesign, respectively. As pointed out in Subsection 3.2, the variable costs for automated redesign are lower than that for manual redesign. As a result, the cost curve for automated redesign has a lower gradient.

Assumption 4. The cumulative manual and automated cost functions are denoted by $C_M(x)$ and $C_A(x)$. They feature different gradients with $(dC_M(x)/dx) > (dC_A(x)/dx) > 0$ and different setup costs $S_A > S_M > 0$.

Both cost functions satisfy Assumption 3. The optimization setting for both approaches is shown in Figure 2.

As described in Subsection 4.1, we consider the variable cost functions $\hat{C}_M(x)$ and $\hat{C}_A(x)$ in the first step. Figure 2 shows that automated process redesign not only induces lower variable costs in a certain RORP, but also enables, in all possible cases,

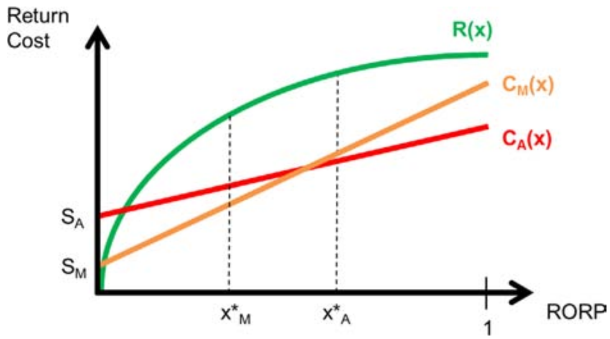

Figure 2.
Optimization, with consideration of manual and automated cost functions

an equal or higher optimal RORP, and thus, an equal or higher contribution margin resulting from the redesign projects. The higher RORP is thereby based on the monotonically increasing shape of the return function $R(x)$, the strictly increasing shape of the cost functions, and the lower gradient of $\hat{C}_A(x)$ $(d\hat{C}_A(x)/\partial x) < (d\hat{C}_M(x)/\partial x)$:

$$\hat{Y}_A(x) \geq \hat{Y}_M(x) \tag{6}$$

To decide whether the superior contribution margin of the higher RORP of automated redesign justifies the higher setup costs S_A (Subsection 3.2), we have to compare the overall yield $Y_A(x_A^*) = \hat{Y}_A(x_A^*) + S_A$ and $Y_M(x_M^*) = \hat{Y}_M(x_M^*) + S_M$ of both approaches in their respective optimal points x_A^*, x_M^*.

We can state the condition for the application of automated process redesign:

$$Y_A(x_A^*) \overset{!}{\geq} Y_M(x_M^*) \tag{7}$$

Thus, the upper limit for the setup costs of automated redesign can be defined as:

$$S_A^{max} = \hat{Y}_A(x_A^*) - \hat{Y}_M(x_M^*) + S_M \tag{8}$$

As we can see in equation (8), the superior contribution margin of automated redesign is opposed to higher setup costs of this approach. Thus, the higher contribution margin for automated redesign, in addition to the setup costs for manual redesign, determines the upper limit for the setup costs of automated redesign.

5. Exemplary application on empirical data

We analyzed a set of project data from a major German financial service provider for an exemplary application of our model. This involved 18 PRPs from the security business[3]. Therefore, these processes had to be evaluated on the costs and returns for each PRP. Since the analyzed financial service provider uses manual process redesign for its PRPs, the data sets did not contain any specific costs for automated process redesign. Therefore, we had to make respective assumptions on the calculation of these costs. These assumptions are based on first rough estimates of experts in the fields of business and IT, and resulted in the definition of best-, worst- and average case scenarios.

As stated earlier, in reality, the measurement of the RORP is discrete because of the selection of the PRPs. Thus, our model is applied on the empirical data in a discrete form. In case the gradient of the cost and return function are identical, all projects with higher returns than costs are to be chosen.

The empirical data contained business cases for each of the 18 PRPs. These were calculated for two years (eight quarters), which represents the given forecasting horizon for the following consideration. A business case is structured as shown in Table I.

Although the actual values were slightly modified to maintain anonymity, the conclusions remain the same. To make the given data compatible to our model:

- we took the given number of person days for the realization of the redesigned process as a proxy of the project size of a PRP;
- we discounted the redesign costs and the returns of the execution of the redesigned processes with a given rate of interest; and

- we only considered returns that could definitely be assigned to process redesign. Thus, we deducted the costs of the configuration phase from the returns of the execution phase to be able to attribute the remaining returns to the analysis and modeling phases.

With these adjustments, we derived the influence of each project on the returns, and ranked all projects based on their marginal effect on the required number of person days. For the comparison of automated and manual process redesign, the interviews mentioned above showed, in a worst-case scenario, that the variable costs of automated redesign should decrease by 30 percent in comparison to their manual counterpart. In the best case, the variable costs of automated redesign showed a decrease of 70 percent. We will therefore consider an average case with the variable costs of automated redesign being half of the variable costs of manual redesign. Instead of providing assumed setup costs, we aim to identify a cost limit for the introduction of automated process redesign. Note that in the data sets, the cost rate for a person day for process redesign increases over the period and thus compensates for the discounting of the costs over multiple periods. As a result, the cost function remains linear.

We can see in Figure 3 that for manual process redesign, the optimal RORP is reached at $x_M^* = 0.25$, which indicates that using 25 percent of the possible person days for process redesign leads to the maximum returns of $R(x_M^*) = €1,843,752$ and redesign costs of $\hat{C}(x_M^*) = €500,500$. The maximal contribution margin for manual redesign is, therefore, $\hat{Y}_M(x_M^*) = €1,343,252$. We can observe that taking into consideration the ranking of all the projects, launching six projects results in the optimal contribution margin.

	Analysis and modeling	Configuration	Execution
Returns	–	–	Additional cash flow of redesigned process
Costs	Required person days multiplied by cost rate	Costs for the realization of redesigned processes	–

Table I.
Design of a business case

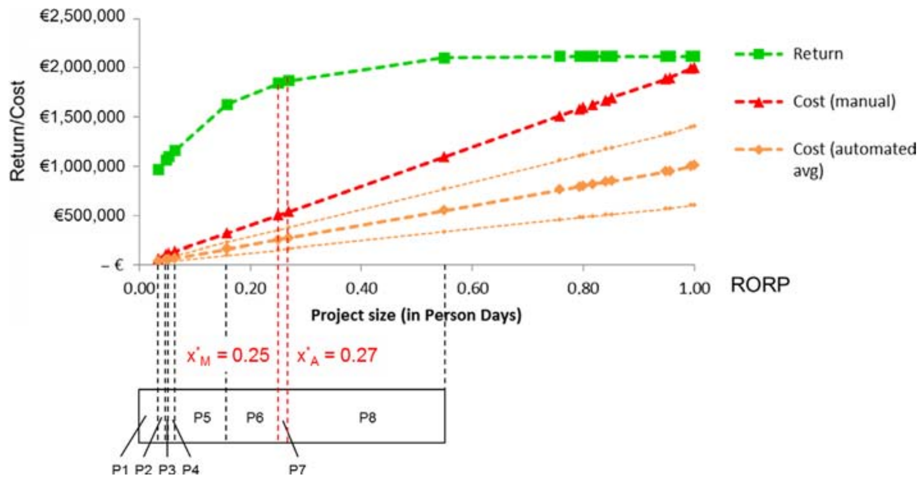

Figure 3.
Representation of project related values

The results differ for the average case of automated redesign (lower bold function in Figure 3). The optimal RORP is located at $(x_A^*) = 0.27$, and this includes project P7, which would not have been conducted with manual process redesign. This leads to the maximum returns of $R(x_A^*) =$ €1,867,274 and redesign costs of $\hat{C}(x_A^*) =$ €268,450. The maximum contribution margin for automated redesign is, therefore, $\hat{Y}_A(x_A^*) =$ €1,598,824.

With the application of automated process redesign, the company could generate an additional contribution margin of €255,572 $(= \hat{Y}_A(x_A^*) - \hat{Y}_M(x_M^*))$. This gain (+19 percent) can be interpreted as the maximum limit for the setup costs for the implementation of automated process redesign, compared to that of manual process redesign.

Although approximately €250,000 does not seem to cover the investment for the automated redesign approach, it must be noted that we only considered 18 data samples. In a real-world company, there is likely to be a much higher number of processes to be redesigned. With an additional contribution margin of 19 percent, the investment should be covered. Further, until this point we have only considered the effect of redesigns over a short period. Over a long-term, the investment in automated redesign is more likely to be economically advantageous, since the setup costs for automated redesign is likely to be far lower after the initial investment.

6. Conclusion and outlook

This paper presents an approach that can be used by companies to estimate the upper limit for investments in manual and automated process redesign. The paper outlines the fundamental characteristics of process redesign and presents an optimization model that shows that sorting PRPs in descending order by the ratio "returns/project size" enables an optimal selection of PRPs based on their respective costs, returns, and project sizes (*RQ1*). We show that the upper limit for investments in automated redesign results from an equal or higher ratio of optimized processes and thus from an equal or higher contribution margin of the automated approach (*RQ2*). We did this by working under certain general assumptions and independently from actual cost and return values. To provide an example for this, we applied our approach to empirical data and showed that the model can be applied to real-world situations and that a higher total contribution margin of process redesign can be achieved by automated process redesign, than by its manual counterpart. Our approach is supposed to help decision makers in the phase of creating business cases by evaluating automated PRPs. As we described theoretically as well as in our example, it is possible to realize more PRPs and thus a higher process maturity using automated redesign than with the traditional manual approach. By furthermore considering the advantages gained through reuse of modeled process actions from the first automated PRPs (which have been partially disregarded so far), even more PRPs can be expected to be realized. Therefore, if a company frequently needs to change its processes, automated redesign can be a means to realize a higher maturity throughout the entire process landscape. From a scientific point of view, we offer a first approach to cover the evaluation of automated PRPs: this needs to be refined and empirically evaluated in further research. Accordingly, it must be acknowledged that we considered only 18 data sets in our example, and hence, we cannot derive statements regarding the whole process landscape of a company. We have concentrated on the financial advantages of process redesign. Therefore, further exploration is necessary whether the semantic annotation of running processes offers any further advantages and what these advantages are. One advantage could be a higher flexibility of processes resulting from a faster adaption to real-world changes. However, we do not analyze this aspect in this paper. Further, analyses of the criteria for choosing automated redesign (e.g. execution, update frequency of processes) are possible avenues for future research. There are several unanswered questions, since there are no examples of completely functional automated process redesigns in a real-world company. Thus, the quality of automatically created process models as well as the handling and usability of the redesign software is still unclear. Moreover, the actual costs of automated redesign have not been confirmed, and it is therefore possible that the automated creation of process models is, by now, more expensive than expected. However, under economic considerations, we have demonstrated that automated process redesign, when applied to real-world companies, can be a promising approach in the field of (semantic) business process redesign.

Notes

1. In reality, the measurement of a RORP will most likely be discrete since PRPs can only be conducted completely or not at all. Therefore, we consider the RORP to be discrete for the theoretical foundation in this section. In the application of the model to a real-world situation (Section 5), we demonstrate how to select the appropriate PRPs according to the optimal RORP.
2. With the given functions and assumptions, it is theoretically possible that the second-order condition is not satisfied for all $\hat{x}$. satisfying the first-order condition (as R(x) is not strictly concave), and thus, there is no unique $\hat{x}$. This would lead to an indifference between all $\hat{x}$ with $(dR(x)/dx) = (d\,\hat{C}(x)/dx)$. We neglect this special case for the following model to analyze the more relevant cases. Therefore, we assume that for $\hat{x}$, the second-order condition is satisfied, and thus, $\hat{x}$ is unique.
3. For further information concerning the projects, see the Appendix.

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(The Appendix follows overleaf.)

Appendix

Table AI.

No.	Project name	Return[a]	Cost[a]	Project size[a] (person days)
1	Order post processing	961,349 (€)	68,250 (€)	60
2	Obligatory corporate action	98,439 (€)	36,400 (€)	24
3	Maturity capacity to contract	31,316 (€)	9,100 (€)	8
4	Automatic branching of analyses sheets	69,738 (€)	22,750 (€)	20
5	Deposit pricing during the year	465,954 (€)	182,000 (€)	160
6	Quotas	216,956 (€)	182,000 (€)	160
7	Book-entry transfers – advisor information (level 1)	23,522 (€)	36,400 (€)	32
8	Manual order cancellation	234,949 (€)	558,285 (€)	480
9	Book-entry transfers – advisor information (levels 2 + 3)	12,194 (€)	417,690 (€)	360
10	Discounts	460 (€)	68,250 (€)	60
11	Order cancellation finishing	–	13,650 (€)	12
12	Provisioning	–	31,850 (€)	28
13	Account closing	–	45,500 (€)	40
14	Security transaction on savings accounts	–	22,750 (€)	20
15	Order entry for annual shareholders meeting	–	191,100 (€)	168
16	Sales communications	–	13,650 (€)	12
17	Order collections from asset management	–	93,730 (€)	64
18	Rights issues repository	–	13,650 (€)	12

Notes: [a]For phases analysis and modeling; cost values and project sizes for manual process redesign