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ABSTRACT

Scientific literature strongly indicates that IT business value is best observed on the level of business processes. However, methodologies by which the contribution of IT can be systematically analyzed on a business processes level are currently insufficient. Therefore, this paper presents a methodology which, proceeding from a given status quo, analyzes and measures changes in IT usage in business processes. The proposed methodology combines the possibilities of the methods Data Envelopment Analysis and Business Process Simulation. An example of application will demonstrate how effects on business process performance resulting from changes in IT usage can be analyzed and measured in a practical application by means of this methodology. The results show that this methodology bears potential for analyzing about the quantification of IT contribution to business value. It allows an assessment of IT business value due to changes in IT usage before an investment decision in IT is made.

Keywords

IT Business Value, Data Envelopment Analysis, Business Process Simulation, Business Process Performance.

INTRODUCTION

In recent years, there has been consensus in literature that IT contributes to business success (Kohli and Grover, 2008). In this context, the productivity paradox of IT is unquestionable disproved (e.g. Brynjolfsson and Hitt, 2000). Since then, the discussion about its economical value, formerly tending towards macro-economy, has been shifted to the corporate level. In this context, Tallon, Kraemer and Gurbaxani (2000) have been able to prove that IT in the form of IT Business Value (ITBV) can clearly contribute to generating value within a corporation. This is the case if organizational concepts such as a consequent process orientation are complementarily supported and IT is directed at the business model realized. Thus, IT application has to be adapted to the support of business processes in the best possible way in order to realize its full potential for effective enhancement of value in terms of business process performance (BPP) (Goeken and Patas, 2009).

As a consequence, the study of ITBV, aimed at an understanding of the effect of a systematic application of IT, has been shifted to the level of business processes. However, although numerous efforts have been made to define its research level, ITBV has not sufficiently been measured to all its extents neither in science nor in practice (Kohli and Grover, 2008). As a consequence, it is advantageous for both scientific and practical purposes to estimate how BPP can be enhanced by changes in IT usage. Within this context this article picks up the research question, how the potential value-generating changes in IT usage can be assessed in terms of BPP.

To answer this research question, this paper presents a new methodology based on a combination of Data Envelopment Analysis (DEA) and Business Process Simulation (BPS) for analyzing BPP (Dohmen and Leyer, 2010). Starting from an analysis of what kind of value is generated by IT, key-performance indicators (KPI) will be included in a DEA input-output model for the measuring of BBP. Effects of changes in IT application will be simulated by BPS and the effects on BPP resulting thereof are measured by use of DEA. This procedure will be demonstrated by the example of a loan application process.

IT BUSINESS VALUE

The IT Business Value Generation Process

Tallon et al. (2000, p.149) define ITBV as „the contribution of IT to firm performance“. This definition is linked to the question of how IT can contribute to the creation of value within a corporation since ITBV is not generated merely by high investment in IT. In this context, Brynjolfsson and Hitt (1995) have shown that certain corporations are more successful when applying their IT than others.

As for the generating process of ITBV, Melville, Gurbaxani and Kraemer (2004) have derived an explanatory model from the Resource-Based View (RBV). According to RBV, each corporation consists of resources combined in a certain way. In the context of ITBV, IT and organizational resources (resources other that IT) are distinguished between. Business processes result from a combination of those organizational resources with IT resources. The value generated by a current business process is registered in the front of BPP. The number of all business processes and their contribution to value generation finally results in Organizational Performance as depicted in Figure 1.

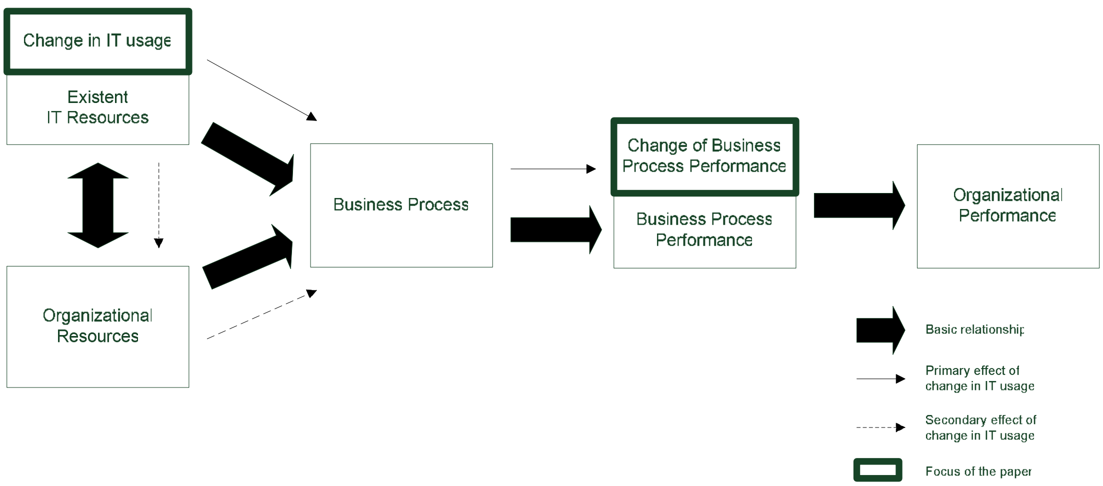

Figure 1. IT Business Value Generation Process according to (Melville et al., 2004)

While resources can be divided into IT and organizational resources, their individual contribution to BPP is difficult to measure as resources are linked to one another in business processes. Yet the effect of a change in IT usage on BPP can be observed. Following the idea of a ceteris-paribus-analysis, the change in BPP is entirely based on the change in IT usage. A change in IT usage within the ITBV leads changes in the business process execution and therefore in BPP. Additionally, secondary effects occur due to the change in IT usage leading to changes even in organizational resources. Thus assessing, the change of BPP due to changes in IT usage should give an indication about the change in ITBV.

Measures for IT Business Value in Terms of Business Process Performance

Exclusive observation of objective measures such as financial measures resulting in market capitalization (Brynjolfsson and Hitt, 1996) or increase in revenues (Brynjolfsson and Hitt, 1995) do not allow value generation to be definitely attributed to IT. Furthermore, this observation frequently occurs on a highly aggregated level. Therefore, some authors tend to apply the perceived ITBV as a yardstick (Shang and Seddon, 2002; Tallon et al., 2000).

While measuring the perceived ITBV has the disadvantage that the result might be subjectively distorted, research within this area suggests possibilities of recognizing those levels, in which an ITBV is to be expected observable. Therefore, studies on the perceived contribution of ITBV can serve as a basis for the identification of these dimensions in which the effects of IT application on BPP can be expected.

As a basis for this, a comprehensive study by Shang and Seddon (2002) defines the business benefits of IT from ERP systems, delivering the best coverage within this topic. Based on perceptions derived from qualitative case studies, these benefits are associated with different levels of observation. Since ERP systems are widespread and fit to cover large parts of business processes, it is assumed that these business benefits should also be reflected within business processes supported by a specific IT-infrastructure. As a consequence, this study serves as a basis for our upcoming analysis.

An understanding of various dimensions of effects an ITBV can be achieved by means of business benefits. Figure 2 presents five dimensions of IT benefits with their respective subordinate extensions identified by Shang and Seddon (2002). The black marks indicate the link of these dimensions to the IT business value generation process. This means, for instance, that the value contribution for organisational resources and IT resources is mainly covered by organizational and managerial IT benefits.

IT Business Benefits				
Organizational	Managerial	IT Infrastructure	Operational	Strategic
1. Support organizational changes 2. Facilitate Business learning 3. Empowerment 4. Built common visions	1. Better resource management, 2. Improved decision making and planning 3. Performance improvement	1. Build business flexibility for current and future changes 2. IT cost reduction 3. Increased IT infrastructure capability	1. Cost reduction, 2. Cycle time reduction, 3. Productivity improvement, 4. Quality improvement, 5. Customer services improvement	1. Support business growth 2. Support business alliance 3. Build business innovations 4. Build cost leadership 5. Generate product differentiation (including customization) 6. Build external linkages

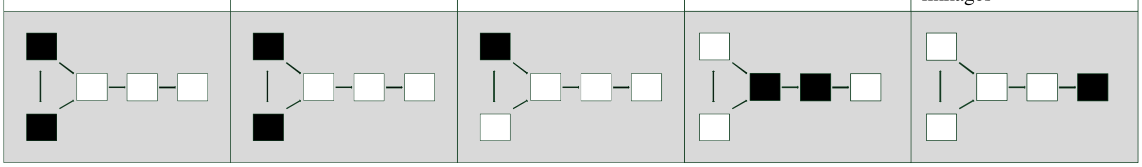

Figure 2. Dimension of IT Business Benefits

According to the business value generation process, the effects of IT benefits occur in organizational resources and IT resources within business processes and, resulting thereof, in BPP. This explains why the study of business processes and their performance provides an adequate level of observation for the evaluation of IT usage. Due to benefits in partly organizational and IT resources, the ITBV is likely to be expressed in the performance of business processes. The study by Shang and Seddon (2002) concludes that IT benefits on an operational level are mostly realized in cost reduction, cycle time reduction, productivity improvement, quality improvement, and customer services improvement. Applicable to BPP, the most objective and hence tangible measures are costs, cycle time and quality (Neely, Gregory and Platts, 2005). Thus, those measures serve as a starting point for measuring ITBV.

Our approach of analyzing the ITBV contribution on an operational level by examining BPP, following the business value generation process, has the advantage that measurement is objectified without having to refer to measures too highly aggregated, such as financial figures. According to this, our view of ITBV is constrained to the operational dimension.

Research Method

The methodology presented in this article follows the design science research paradigm obeying the framework proposed by Venable (2006). This framework is based on the ideas of March and Smith (1995) and Hevner, March, Park and Ram (2004), but more specifically concerned with the role of theory building and evaluation. According to the framework, design research is conducted as follows: (1) *Theory building* delivers a utility theory which specifies how the proposed solution technology helps to solve the identified research question. (2) Based on theory building, the *solution technology* – also named IT artefact (Hevner et al., 2004) – has to be developed. (3) The *evaluation* of the solution technology can be conducted in a naturalistic way (e.g. case studies) or artificial way (e.g. computer simulations). (4) The *results of the evaluation* should be used to enhance the derived utility theory and the solution technology.

In line with Venable (2006), the development of what he calls a "new solution technology" will be the primary goal of this paper. We claim that our approach will help analyze and measure ITBV on a business process level due to changes in IT usage. Referring to Becker, Grob, Klein, Kuchen, Müller-Funk and Vossen (2001), the proposed solution technology in this paper is denoted a methodology incorporating different methods, namely DEA and BPS, a general framework of application and rules how to combine these methods. Besides the conceptualization of the proposed methodology, an example for its application for a loan application process will be provided in this paper.

METHODOLOGY FOR ANALYZING AND MEASURING IT VALUE FOR BUSINESS PROCESSES

Previous methods for measuring the BPP suffer from the problem of aggregating performance indicators and how to include multiple indicators simultaneously (Goeken and Patas, 2009). For this purpose it is advantageous to look at classical efficiency analysis, e.g. in the field of frontier analysis, where multiple input and output factors are included in one analysis (Cooper, Seiford and Tone, 2007). Within this context however, most studies focus on an organizational context and only few studies can be found that apply frontier analysis to process level (Frei and Harker, 1999). Having identified this lack of research, Burger and Moormann (2010) present a method to measure efficiency on a process level by using Data Envelopment Analysis (DEA). It is a non-parametric method, developed by Charnes, Cooper and Rhodes (1978) for measuring the efficiency of so-called Decision Making Units (DMUs) in relation to each other. BPP will be taken into account for this paper as for the efficiency in process execution. In the approach of Burger and Moormann (2010) single transactions (the objects or process instances passing through the process) serve as DMUs in a DEA. Applying this method yields an empirical production function of best practice transactions and the transactions' inefficiency is determined by their distance from this frontier. As a result, an average efficiency score for the process can be calculated. Instead of being based on simple metrics, this method allows quantitative measurement of process efficiency from the perspective of production theory, taking into account multiple input and output factors simultaneously.

For a more objective measurement of the ITBV in terms of BPP, our methodology is aimed at using the advantages of frontier analysis as a method for process measurement. In order to be able to assess BPP changes due to changes in IT usage beforehand, these scenarios can be analyzed in a simulation environment. For this purpose, BPS provides the opportunity to analyze the ITBV in terms of simulation scenarios and its influence on BPP, hence analyzing the "black box" of throughput (Serrano and den Hengst, 2005). Typically, BPS aims at evaluating consequences of alternative process structures, changes of demand on KPIs and bottlenecks within a process (Banks, Carson and Nelson, 1996). Consequently, the use of BPS allows a basic understanding of processes, generating options for changes and an evaluation of effects of these changes (Doomun and Jungum, 2008). Applying DEA as a measurement method allows the assessment of changes in BPP due to changes in the process design simulated by BPS. Figure 3 shows a conceptualization of the proposed methodology.

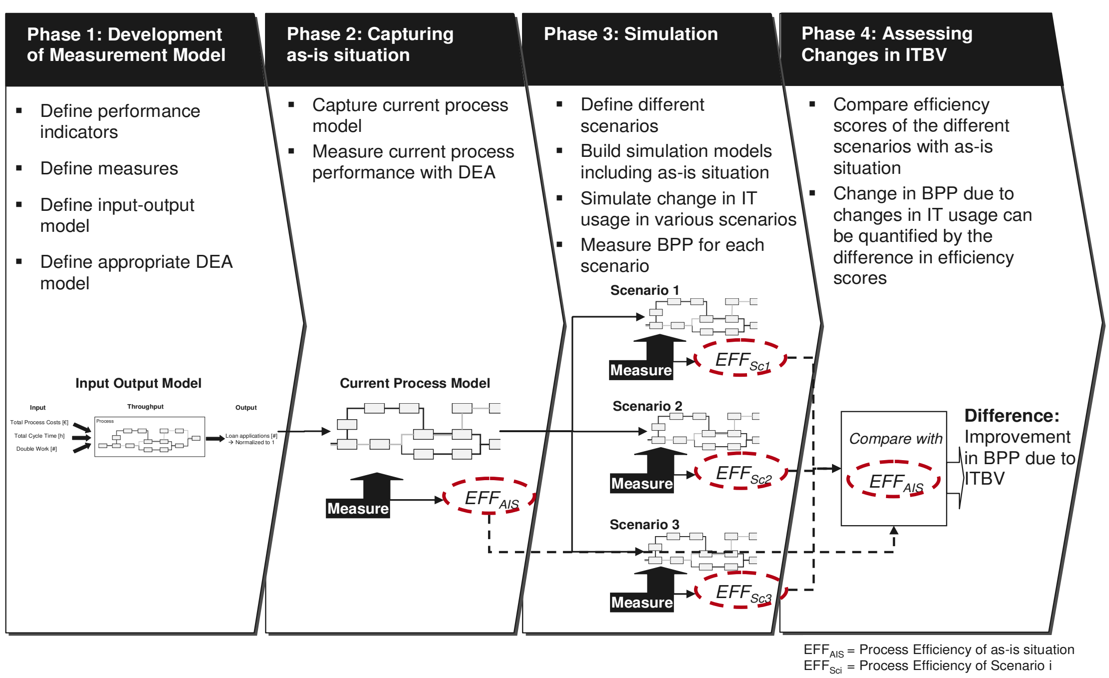

Figure 3. Conceptualization of the proposed Methodology for Assessing the Improvement in BPP due to Changes in IT Usage

An application of either DEA or BPS is very useful but delivers answers to different dimensions (either process efficiency in terms of an input-output model or simulated input-output data for different scenarios). Combinations of DEA and BPS can be found in the literature (e.g. Braglia and Petroni, 1999; Greasley, 2003; McMullen and Frazier, 1998). However, those suffer from methodological constraints making them inapplicable in the context of analysis. In this context, Dohmen and Leyer (2010) show a new methodology combining DEA and BPS to analyze the efficiency of business processes. Their methodology serves as a basis in the context of this paper.

The general framework of the proposed methodology can be summarized as follows. Phase 1 includes the definition of the measurement model to be applied. Phase 2 consists of the analysis of the status quo, i.e. capturing the as-is situation in terms of the current BPP and the process model which is needed as the input of the simulation model. Phase 3 then incorporates the actual simulation. Here, simulation models for the as-is situation and what-if scenarios have to be implemented for simulating certain changes in IT usage. Subsequently, the BPP under each simulated scenario is measured by DEA. Finally, in Phase 4 the results of the simulation scenarios are compared against the BPP measured for the as-is situation. The difference in performance scores can be assigned to BPP improvements due to changes in IT usage. This methodology should be understood as a tool that can be used from the perspective of an organization in order to assess the value of e.g. a planned investment in IT or changes in IT usage.

DEMONSTRATION OF THE METHODOLOGY AT THE EXAMPLE OF THE LOAN APPLICATION PROCESS

In order to demonstrate the functionality of the proposed methodology, the example of a typical loan application process of a bank will be used. Loan processing is a suitable example as many banks still lack in using opportunities to implement IT systems but still have a long way to reach a satisfactory BPP. In the example exhibited in Figure 4, the customer has to provide documents when applying for a loan after a successful sales talk. During the process step of data acquisition and check-up of documents several tasks are performed eventually leading to back loops if some data or documents are not complete or implausible. Afterwards a decision for or against the granting of the loan request is made (scoring). Afterwards all administrative tasks for processing the loan application are performed and the customer is required to sign a contract. Then s/he will receive the granted amount.

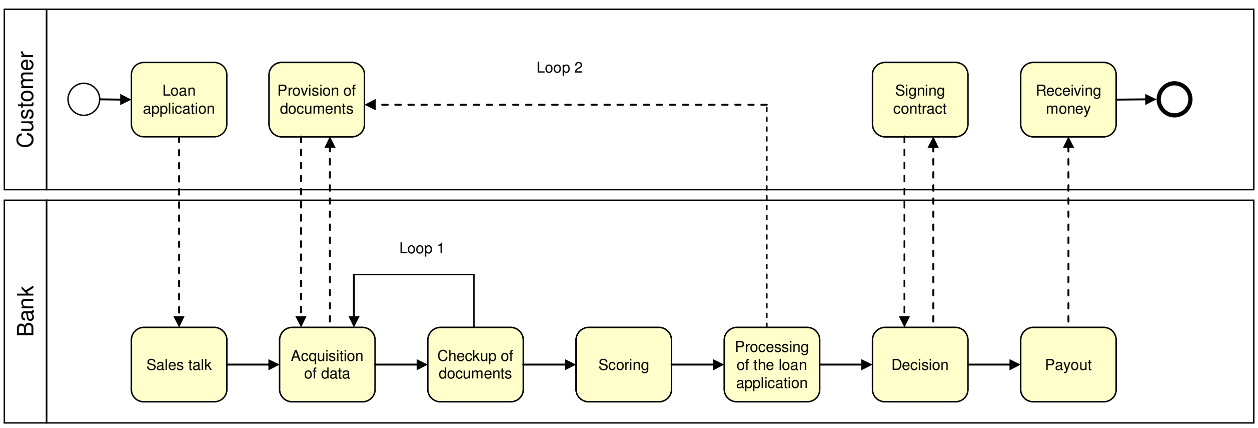

Figure 4. Example of a Loan Application Process

Phase 1: Development of Measurement Model

The *first step* of phase 1 incorporates the definition of measures capturing the BPP from an operational perspective. Crucial in this context is to define measures that (a) capture dimensions of BPP on which IT can have an influence, (b) can be mapped in an input-output model, and (c) are employable in a BPS. Following the benefits of IT in the operational dimension, according to Shang and Seddon (2002), we focus on the three main performance indicators of business processes: costs, time and quality (Neely et al., 2005). Customer service improvements and productivity improvements cannot be captured in the simulation for our example of the loan application process and, as a consequence, are not be included. As striking indicator for quality the amount of double work at the first loop (check-up of documents to acquisition of data) and at the second loop (processing of the loan application to provision of documents) are chosen.

The *second step* includes the definition of the input-output model and the choice of the appropriate DEA-model. The aim for increasing BPP is to minimize the input factors given a certain output, i.e. a certain amount of process instances processed. Within this context, technical efficiency takes into account the optimal mix of the amount of inputs and outputs without including any factor prices (Cooper et al., 2007). There is no distinction of factor prices between different process instances of the loan application process, thus analyzing technical efficiency is appropriate here. If the process under analysis is considered to exhibit constant returns on scale the "CCR-model" should be chosen as a DEA model (Charnes et al., 1978).

An extension to variable return of scales is easily applicable by using the "BCC-model" (Banker, Charnes and Cooper, 1984). This however has to be decided from case. In any case a input-oriented model has to be chosen, since the objective is to minimize the mix of inputs for a given output. Following a pure input-orientation, the output is normalized to the integer value 1 (Dyson, Allen, Camaho, Podinovski, Sarrico and Shale, 2001). Since the DEA is applied on a process instances level, the output of 1 can be interpreted as a full processing of the process instance. Figure 5 shows the conceptual input-output-model for the loan application process.

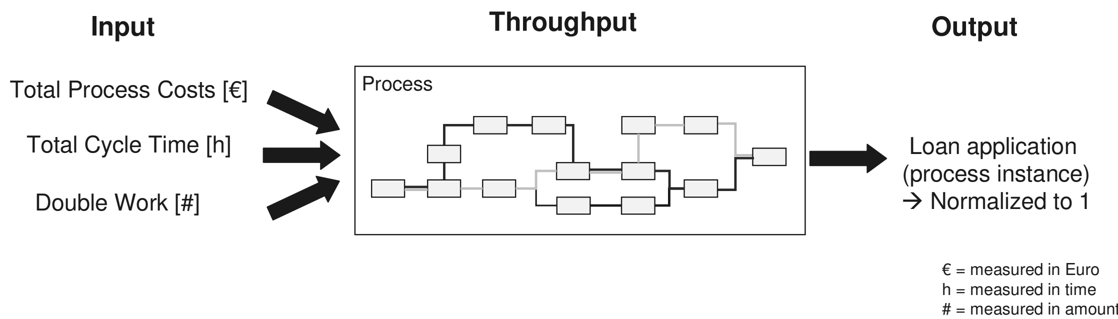

Figure 5. DEA Input-Output Model for the Loan Application Process

The result after phase 1 is a measurement model which includes the definition of the measures, the input-output-model, and the relevant DEA model to be applied.

Phase 2: Capturing Status Quo: Assess Current Business Process Performance and Build Simulation Model

As the *first step*, the DEA model described in the previous section is applied to the loan application process. The result is a DEA efficiency score between 0 and 1 for each process instance (DMU). An efficiency score of 1.0 indicates that a process instance is fully efficient, whereas a score of 0.8 indicates that there is an inefficiency of 20% in comparison to the reference process instance on the best practice frontier. An aggregation of the process instances' efficiency scores by averaging them gathers the as-is situation of BPP.

In preparation of the upcoming simulation, in the *second step* the current process model has to be identified and implemented as a simulation model (e.g. Aguilar, Rautert and Pater, 1999). This incorporates the mapping of different process steps, the interdependencies between the steps and probabilities of process instances to enter each process step. The BPP measured for the as-is simulation model should be consistent with the results of the real process, measured in the previous step.

The results after phase 2 are an average process efficiency score as well as a valid simulation model for the process under analysis.

Phase 3: Simulate and Measure the Impact of IT Usage by applying Business Process Simulation

In case of problems with the loan processing (e.g. cycle time is too high) the bank has numerous possibilities to improve the BPP. As discussed in this paper, one possibility is a change in IT usage. One option could be the semi-automation of the process "Checkup of documents". This means that simple documents could be checked automatically by an IT application for the existence of all required data and for basic plausibility. For complex documents or in case of any problems, an employee is still required to conduct an advanced checkup. The idea is that the IT system is better at doing the basic checkup and the employee can focus on the complicated documents. However, the impact of this change in IT usage on BPP is not straight-forward due to cause and effect relationships between orders, resources and customers (Rozinat, Wynn, van der Aalst, ter Hofstede and Fidge, 2009). For this purpose, the bank can simulate if and to what extent the intended change in IT usage leads to an improvement in BPP.

The *first step* is to apply the proposed change to the simulation model by means of what-if questions for applying a BPS (Bratley, Fox and Schrage, 1987). In the situation described, a new process step will be added to the simulation model - the "Basic automatic checkup of documents". This leads to an adjustment of different parameters in the simulation model. Figure 6 shows the example of one adjustment leading to the definition of scenario 1. Since the results of the simulation for the loan application process rely on the assumption about improvements in double work due to the change in IT usage, it is advisable to define different scenarios capturing different expectations. A scenario is based on assumptions which have to be made in advance by the user of the methodology. These assumptions can be based on past experience or expectations. In this case, a major characteristic of a scenario should be the reaction of employees according to the proposed change. This allows an assessment of the sensitivity of BPP due to a specific change in IT usage.

In scenario 1, for example, the new IT system filters 8 per cent of non-conformant documents before the advanced checkup will be performed by an employee. This leads to a reduced cycle time for this process step. In this context also the "Processing of loan application" has to be changed, as the automated IT system discovers more mistakes than the employee did before in the as-is situation. This change reduces the cycle time due to less second checkups as well as the probability of a back loop to the customer. The result will be a new simulation model as shown in the what-if scenario 1. The secondary effects, such as a reduced usage of "Scoring" or the changed workload of later steps like "Decision" and "Payment" due to a faster processing, will become apparent after a simulation.

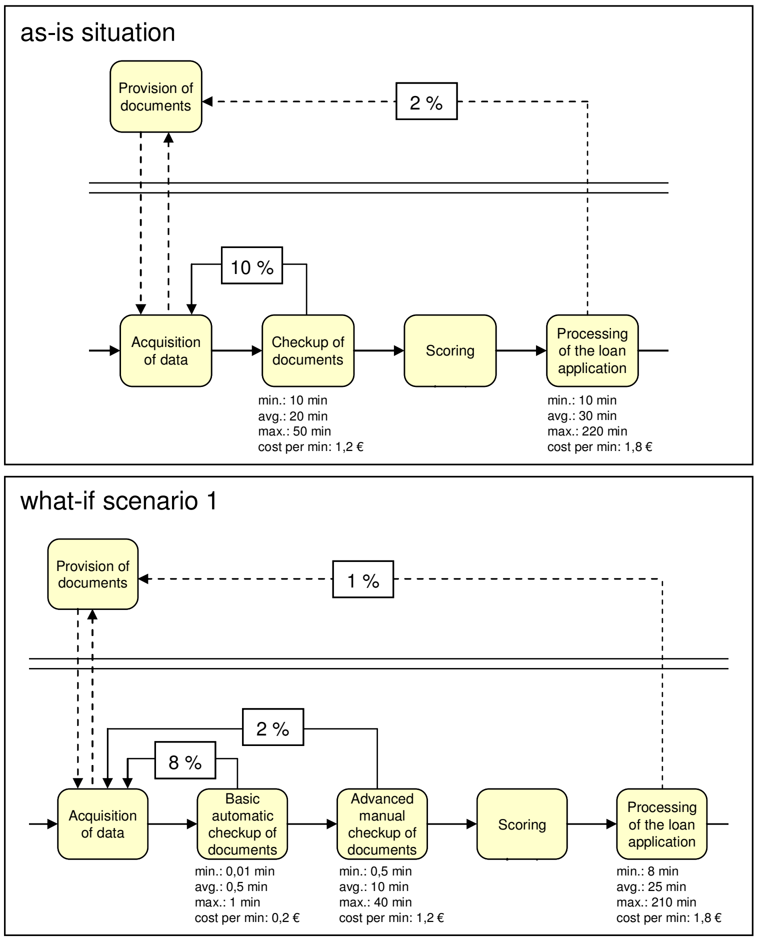

Figure 6. Changes in the Simulation Model According to one Scenario

The *second step* is to run the simulation itself for each scenario defined (Roy and Meikle, 1995). A comparison of different simulation models can only take place if the loan applications used as an input for the simulation are the same. Additionally, the as-is situation and the what-if scenarios should be checked within different amounts of process instances in a certain period of time. For instance, this could be a low and high amount of loan applications derived from historical data. As a result of phase 2, data as exhibited in Figure 7 can be expected.

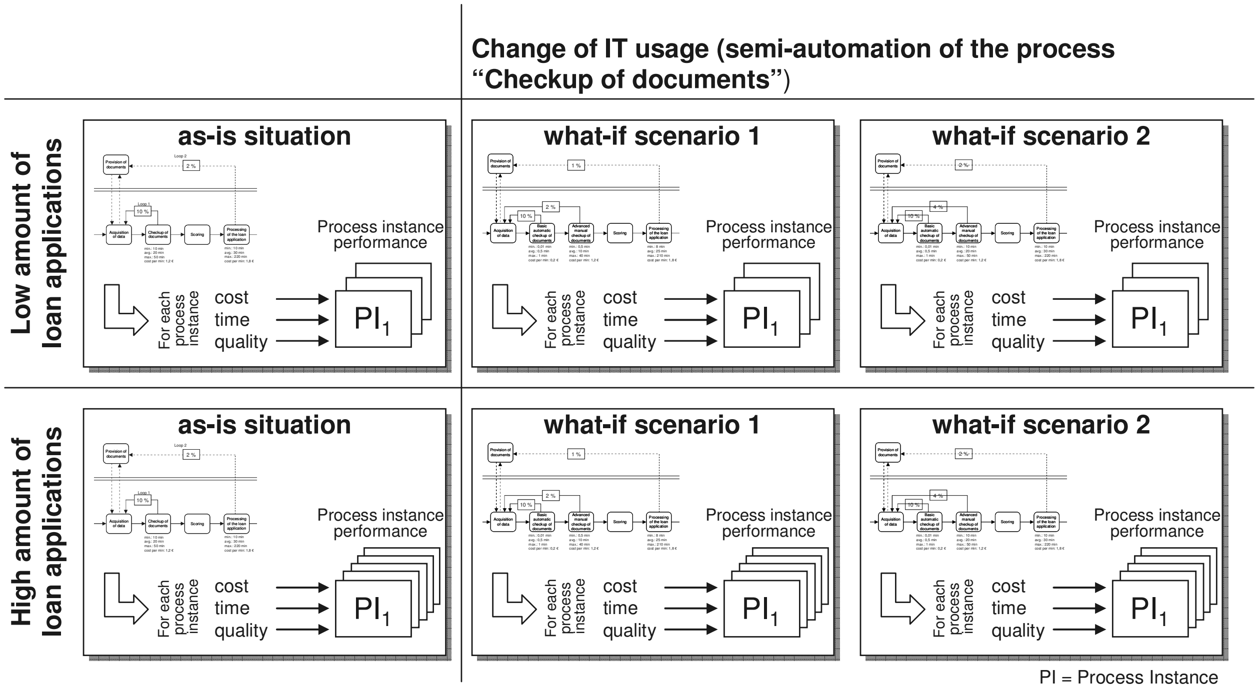

Figure 7. Sample Results of the Simulation

In applying BPS, each ITBV contribution has to be analyzed independently in order to be able to assign the BPP changes to the specific changes in IT usage and to allow conclusions in terms of a ceteris-paribus-analysis. All changes in the IT usage that are assumed to have an influence on the input-output-relation can be modeled now and the impact under different scenarios is observed. By doing so, BPS simulates changes in the process throughput under different scenarios and provides new input-to-output data for the whole process and single process instances.

After simulation of what-if scenarios, results can be evaluated by using DEA again. This can be achieved by providing the simulation data per process instance and measuring the BPP of the what-if scenarios using DEA according to Burger and Moormann (2010).

Phase 4: Evaluate the Improvement in Business Process Performance due to Business Value of IT

The simulation in phase 3 delivers the performance in terms of time, cost and quality for each loan application for the proposed change in IT usage within different scenarios. The expected impact on the process flow and the BPP under each scenario is calculated using DEA. In the final phase, these results are compared to the BPP measured under the as-is situation. The difference in the average efficiency scores between the what-if scenarios and the status quo gives indication about the improvement in BPP due to the proposed change in IT usage. Figure 8 demonstrates this calculation procedure for two what-if scenarios.

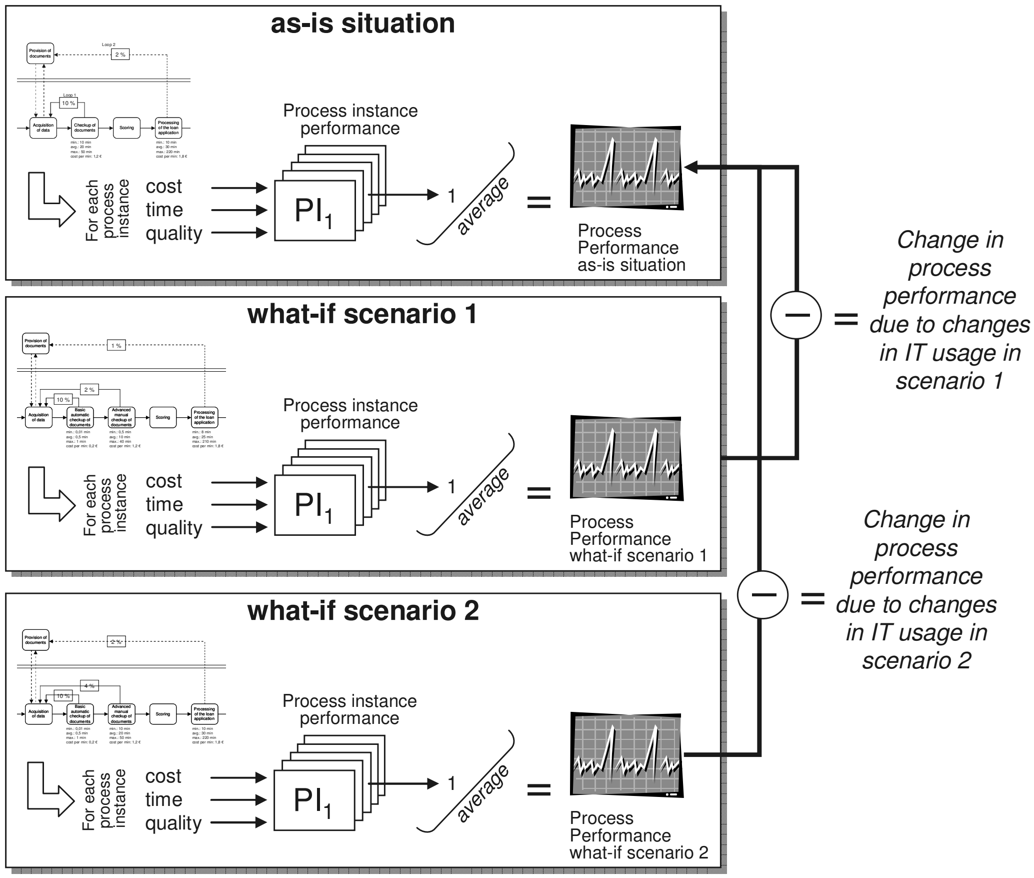

Figure 8. Comparison of BPP measurements

CONCLUSION

It is still an open question and a task of scientific work in IS research to develop methods or approaches to measure the ITBV. The proposed methodology can serve as a basis for any company to assess the impact of changes in IT usage in terms of BPP. It entails some advantages as shown in the example of application. First, the presented methodology allows to aggregate different performance indicators by using DEA for measuring BPP. Second, it is able to clearly separate the changes in BPP due to changes in IT usage by analyzing different what-if scenarios in a simulation. Third, a methodological alignment of the methods used (DEA and BPS) in a generic methodology serves as a basic guideline for assessing ITBV in terms of BPP. However, it has to be adjusted and refined from case to case, as has been shown in this paper by example of a loan application process in a bank.

Our methodology incorporates some limitations as well. The simulation performed depends on assumptions, which – if not well-founded – might lead to misleading results. Furthermore the combination of DEA and BPS only delivers reliable results if and only if the same input and output variables are used for the as-is situation and each what-if scenario. Moreover, using a simulation approach only allows considering a what-if scenario but not the ascertainment of the ITBV in a real context. Being an ongoing research project, in a next step it will be continued with the evaluation of the methodology by means of a case study incorporating real production data of a loan application process of a German bank.

Generally, this paper contributes to the science by taking up the discussion about measuring the ITBV and provides a new methodological approach that fits into this field of research. From a practical point of view, the methodology presented clearly strives from the fact that it allows the assessment of ITBV due to changes in IT usage before an actual investment. Even though the simulation is based on certain assumptions and the value of results depends on the strength of assumptions made by the applier, it provides a valuable tool for both operations and IT management.

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