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Simulation Approach for Managing and Analyzing Dynamic Complexities in Business Process Change Projects

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Preface

This doctoral thesis was written as a part of my research activity at the Chair for Information Systems at the Technische Universität München. Over the years, I have come to know many people in the research field, some of them became my friends. With this preface, I would like to take the opportunity to thank those who have supported, motivated and encouraged me during my writing of this thesis.

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Most importantly, I would like to thank my family. Firstly, my husband Chris, whose support, love and patience have helped me at every stage of my personal and academic life. Also our daughter Veronika, through whom I have learned to be more patient and my parents Maria and Ladislav and my brother Marian, who believed in me and encouraged me to go my own way. Without you all I would not have achieved what I have achieved.

Zuzana Rosenberg

Abstract

Motivation: Despite years of experience in business process change (BPC) implementations, organizations involved in such projects frequently fail to achieve their intended goals. Such failures have severe consequences for the respective organization, ranging from a loss of competitive advantage to financial losses or even extinction. BPC is therefore characterized by complex initiatives that often have unknown outcomes. Even though many BPC researchers have addressed the topic of BPC in the last three decades, the high failure rates (60% to 80%) indicate that not much clarity on the determinants driving successful BPC exist. We further argue, that there is an insufficient understanding of dynamic and complex interactions arising from BPC project factors and their relationships and that this is one of the major causes of the high failure rates of such projects. Therefore, the complexity and dynamics inherent in BPC projects cannot be analyzed in a straightforward manner. They have, moreover, to be supported by an approach capable of capturing and simulating the complex and dynamic settings of BPC projects. The aim of this doctoral thesis is to explore the dynamic complexities inherent in BPC projects by proposing a simulation approach.

Research Approach: For the purposes of this doctoral thesis we employ a mixed-methods research strategy that combines both qualitative and quantitative data analysis. A mixed-methods research strategy tends to provide richer insights into various phenomena of interest (such as BPC) that cannot be fully understood either by a qualitative or a quantitative method. This thesis adopted a rather pragmatic view in analyzing the complex and dynamic nature of BPC projects. The methods employed for answering the research questions were case-survey and system dynamics (SD). The case-survey method was applied to systematically investigate factors and for examining the causal relationships between these factors. SD was used for capturing the complex and dynamic nature of BPC projects and for policy analyses.

Results: The publications referenced in this doctoral thesis offer insights into how system dynamics (SD) simulation models can improve our understanding and management of the dynamic complexity inherent in BPC projects. Specifically, we propose an SD simulation model as an experimental tool for observing and analyzing the implications of different “what if” policies and procedures. The proposed SD models provide a graphical display that can be edited interactively and animated to demonstrate the dynamics of different decisions. The resulting SD model is based on empirical findings compiled from 130 case studies.

Contributions: The contributions to this doctoral thesis were in several forms. We systematically synthesized BPC knowledge which was mainly dispersed in single BPC case studies. More specifically, we extended the theory of BPC by identifying impact factors driving BPC project success and by exploring causal relationships between these factors. We also show that SD is a helpful approach when analyzing and managing complex and dynamic phenomena such as BPC. The proposed empirical SD simulation model provides an opportunity to practice and analyze various decision-making cases and to observe their effects in real time. BPC researchers and practitioners can run concrete SD simulations using differing variable configurations, each representing a certain set of managerial policies. Experimenting with SD simulation models enables decision-makers to understand important effects, interrelationships and complex feedback loops in a more effective manner. SD models provide them with a graphical display that can be edited interactively and animated in order to demonstrate the dynamics and complexity of different decisions. We have also demonstrated the usefulness of the case-survey method in BPC and SD research domains.

Study Limitations: The publications included within this doctoral thesis contain some known weaknesses of the case-survey and SD methods. Especially the coding process which is a time and resource consuming process and requires skilled personnel. Another limitation refers to a certain degree of personal interpretation during the coding process. However, the established consensus gives us some confidence in the individual disparities. There are also limitations associated with the proposed SD model. To propose a usable SD model, information might be aggregated and details omitted resulting in a simplified representation of reality. Any quantification of relationships enabled by the resulting SD simulation models may vary substantially due to specific organization characteristics or the organization's industry and thus might represent only an approximation of a real project environment.

Future Research: Given the results and the limitations of this thesis, we suggest several fruitful avenues for future research. In the light of the problems encountered in the relative strengths of the loops in causal loop diagrams, it would be useful to quantify these effects and determine the structural dominance of them. A more nuanced coding process based on multi-item scales, instead of binary codes, would indicate which variables are significant and which are not, for the overall BPC project success. To gather additional empirical data for parameterizing and calibrating the model, it would be fruitful to apply the model at an industry partner. Another interesting avenue for future research would be an extension of the proposed SD model into a business game. Here, an integration of the various types of simulation methods such as SD, discrete event or agent based could be brought together.

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List of Abbreviations

AB	Agent Based
BPC	Business Process Change
BPI	Business Process Improvement
BPM	Business Process Management
BPR	Business Process Reengineering
BPT	Business Process Transformation
CLD	Causal Loop Diagram
CPI	Continuous Process Improvement
CSF	Critical Success Factor
DE	Discrete Event
DS	Dynamic Systems
e.g.	For example
ERP	Enterprise Resource Planning
i.e.	That is
IT	Information Technology
P	Publication
PSS	Product Service System
RBT	Resource-Based Theory
RQ	Research Question
SD	System Dynamics
SDDDSS	System Dynamics Decision Support System
SFD	Stock and Flow Diagram
TCO	Total Cost of Ownership
TQM	Total Quality Management

PART A

1 Introduction

The aim of this doctoral thesis is to explore the dynamic complexities inherent in business process change (BPC) projects by proposing a simulation approach. The following chapter motivates this thesis and introduces the problem statement and gives an overview of the research objective and the structure of this thesis.

1.1 Motivation

"To improve is to change; to be perfect is to change often." Winston S. Churchill

BPC has gained increasing importance in public and private organizations, as every organization wants to achieve efficiency and effectiveness in reducing the cost of production, improving the quality of products and services and providing timely deliveries and rollouts of products and services to their customers (Al-Mashari, Irani, & Zairi, 2001). BPC or business process improvement[1] (BPI) is therefore seen as a panacea for companies to remain competitive in a turbulent and highly competitive business environment (Weerakkody, Janssen, & Dwivedi, 2011). BPC presents a management concept that involves any type of process change – revolutionary/radical or evolutionary/continuous (Grover, Kettinger, & Teng, 2000; Grover & Markus, 2008).

There exists a wide range of benefits that organizations expect to achieve from business process improvements. Some examples of BPC's benefits were highlighted in the press: *"Wal-Mart reduces restocking time from six weeks to thirty-six hours" or* "*Taco Bell's sales soars from $500 million to $3 billion*" (Grover & Malhotra, 1997).

These benefits range from organizational improvements to individual improvements.

Organizational improvements, such as:

- Increased product quality (Geier, 1997; Shin & Jemella, 2002),
- Increased customer satisfaction (Dey, 2001; Gadd & Oakland, 1995; Hammer & Champy, 1993; Lee & Chuah, 2001; Thong, Yap, & Seah, 2000),
- Reduced cycle times (Halachmi, 1995; Hughes, Scott, & Golden, 2006; Kennedy & Sidwell, 2001; Paper, Rodger, & Pendharkar, 2001; Proctor & Gray, 2006),
- Reduced costs (Harvey, 1994; Hesson, 2007; Jackson, 1995; Kontio, 2007; Melvin, 1993).

Individual improvements, such as:

- Increased employee morale (El Sawy & Bowles, 1997; Harvey, 1994; Kennedy, 1994; Newman, Cowling, & Leigh, 1998; Paper, 1997),
- Increased process knowledge (Caron, Stoddard, & Jarvenpaa, 1994; Lai, Khoong, & Aw, 1999; Melvin, 1993).

[1] Both definitions are used synonymously in this thesis.

Despite these commendable benefits, BPC initiatives are notorious for bearing a high risk of failure (Hill & McCoy, 2011) since they are extremely complex, consist of multiple interdependent components, are highly dynamic, involve multiple feedback processes and involve both hard and soft data as well. Literature reports 60% to 80% of all BPC projects fail to attain their intended goals (Al-Mashari et al., 2001; Berman et al., 2008; Koch & Hess, 2003; Trkman, 2010).

Two prominent examples of BPC project failure[2] highlight these issues: In 1996, FoxMeyer Drug Organization invested $65 Million in a computer system for managing its critical operations expecting to save $40-$50 Million annually, as well as to gain a competitive advantage (Jesitus, 1997). However, after its major client, Phar-Mor went bankrupt FoxMeyer signed a major new client contract which resulted in significant changes to the projects. The organization was overwhelmed by the costs of hardware, software and consultant fees. After the costs exceeded $100 million the project was declared a failure. Later FoxMeyer was declared bankrupt and was sold to its major competitor McKesson Corp (Jesitus, 1997). Another example is provided by the British supermarket giant Sainsbury's who in 2003 decided to implement an automated barcode-based fulfillment system in one of its distribution centers. The BPC project aimed to increase efficiency and streamline operations. After implementation in 2003, the system was described as "horrendous" as a result of barcode-reading errors that were occurring. Even though Sainsbury's organization claimed the system was operating as intended, a mere two years later the entire project was abandoned and the organization wrote-off £150 Million in IT costs (Widman, 2008).

Although BPC projects might be concerned with extreme financial losses, the major reason for conducting BPC is the fact that organizations need to adapt to new environmental demands, new technological advances, new customer demands, new market structures or new legislation policies (Haveman, 1992). If these companies do not adapt quickly, they are likely to jeopardize their organizational profits or even face a potential extinction (Fountain, 2007; Sims, 2010). Therefore, the need for organizations to adapt their business processes, to reflect changes imposed by environmental forces and influences, is one of the major reasons why organizations rely on BPC.

Given the high risk of failure and its severe consequences for the respective organization BPC has gained considerable importance in recent years among researchers and practitioners. A number of researchers studied factors affecting the success, or failure, of BPC projects and this resulted in different models (e.g. Grover, 1999; Guha et al., 1997; Huizing, Koster, & Bouman, 1997; Kettinger & Grover, 1995; Skerlavaj et al., 2007). However, the majority of these models

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[2] The definition whether BPC projects are failures or successes is gray area, leading to several interpretations. For the purposes of this thesis we use the five levels of project completion as proposed by Yetton et al. (2000). (1) smoothly completed (means that project was completed according to the initial plan), (2) partially abandoned (means that the original extent of the project is reduced but there is still no cut in the project specification), (3) significantly redefined (means that the scope, budget or schedule are redefined and the project declared as completed), (4) substantially abandoned (a major reduction of the project scope) and (5) totally abandoned (all efforts on the project are terminated prior to full implementation).

for BPC do not consider an adequate theory or method and the models are rather “atheoretical” (Jurisch et al., 2012). Thus, the results remain rather inconclusive with few reliable generalizations. Other BPC researchers analyzed specific causal relations such as the impact of information technology (IT) on the overall BPC success (Grover et al., 1998; Huizing, Koster, & Bouman, 1997) or the impact of communication in programs on acceptance of change projects (e.g. Barrett, 2002; Belmiro et al., 2000; Klein, 1996). However, focusing only on specific relationships does not allow for capturing the complexity and dynamics of BPC projects.

1.2 Problem Statement

Given the high failure rate of BPC projects, we argue that there is a lack of conceptual understanding of the impact factors influencing a successful BPC as well as of the underlying cause and effect relations. We identify three fundamental challenges that have not been addressed in extant BPC research:

<u>Challenge 1:</u> *Lack of understanding of the impact factors for a successful BPC project*

Due to the large number of failed BPC projects and programs, a number of researchers call for a better understanding of its critical success factors (CSFs) (e.g. Ariyachandra & Frolick, 2008; Bandara et al., 2007; Trkman, 2010). Thus, the research on CSFs in BPC has been one of the earliest and most actively studied topics (Trkman, 2010). For example, past research on CSFs in BPC projects has mainly focused on technical aspects, highlighting IT for automation purposes (Davenport & Short, 1990). Recent studies, however, emphasize that the core factors are outside IT, such as top management support, communication, or inter-departmental cooperation and end-user training (e.g. Lu, Huang, & Heng, 2006; Ariyachandra & Frolick, 2008; Bandara et al., 2007; Karimi, Somers, & Bhattacherjee, 2007).

In summary, the results of these publications mainly offer fairly similar and rather general CSFs for BPC (Trkman, 2010). Furthermore, our initial analysis reveals that even though theoretical and practical evidence highlights the importance of the project scope, none of the prominent BPC models (i.e. Guha et al., 1997; Kettinger & Grover, 1995) incorporates it as a CSF for BPC (Kristekova et al., 2012).

In addition, Trkman (2010) argues that the identified CSFs for BPC are often case-specific; i.e. that it has been rarely confirmed whether the CSFs of an organization operating in one country, or one industry, can be applied to those operating in other countries or industries. Furthermore, these studies lack any theoretical explanation as to the choice of a specific type of organization which limits the generalizability of their findings (Trkman, 2010). Overall this insufficient understanding is increased by a lack of a systematic theoretical approach (Näslund, 2008).

Despite these shortcomings the BPC research field has generated myriad works and has built up a wealth of knowledge over the last three decades. A large number of explorative case studies have evolved (e.g. Al-Hudhaif, 2009; Hesson, Al-Ameed, & Samaka, 2007; Palmberg, 2010; Proctor & Gray, 2006; Stemberger, Kovacic, & Jaklic, 2007). Even though these case studies report back valuable insights about the success or failure of BPC initiatives, the insights have remained rather unexplored (Jurisch et al., 2013). Consolidating the findings of these case studies using a systematic meta-analytical approach will provide empirical evidence of the main impact factors for successful BPC. The empirical identification of the main impact factors might be used in behavioral science for theory developments and in design science for the investigation of the actual effects, the efficiency and other characteristics (Fettke, Houv, & Loos, 2010).

Challenge 2: *Focus only on one or few specific causal relations*

The issue of causal relationships within organizational changes has gained much attention since the advent of BPC (Marjanovic, 2000; Ozcelik, 2010; Sarker, Sarker, & Sidorova, 2006). One of the most studied relationships in BPC is the role of IT. Many BPC researchers have centered their research on the business value of IT and the effect of IT on business performance (Brynjolfsson, 1993; Carr, 2003; Davenport & Short, 1990; Scheepers & Scheepers, 2008). Many authors argue that IT should be measured at the activity or process level to ascertain the prime effects on business value (Karimi, Somers, & Bhattacherjee, 2007; Melville, Kraemer, & Gurbaxani, 2004; Ray, Muhanna, & Barney, 2007). Davenport and Short (1990) propose a recursive relationship between IT and BPC; i.e. that, on the one hand, IT is needed to support the changed business processes and, on the other hand, it should be considered as an enabler for future BPC capabilities.

Recently researchers and practitioners have become aware of the effects of BPC on employees. This is because BPC projects are complex initiatives, often with unknown outcomes and employees may be unsure of the implications imposed by personnel and organizational changes. For that reason several BPC researchers (Al-Mashari & Zairi, 2000; Lee & Chuah, 2001; Marjanovic, 2000; Ozcelik, 2010) have examined the relationship of communicating changes to employees and its positive effect on the overall success of BPC initiatives. Sarker, Sarker and Sidorova (2006) analyzed the interactions between IT and human processes such as communication, leadership and politics in failed BPC projects.

Although to date literally all BPC researchers allude to the critical importance of the relationship (Al-Mashari & Zairi, 2000; Lee & Chuah, 2001; Marjanovic, 2000; Ozcelik, 2010), little research has been directed towards a thorough examination and analysis of interrelationships inherent in BPC projects (Jurisch, Ikas, et al., 2012; Trkman, 2010). The studies reported by Al-Mashari & Zairi (2000), Lee & Chuah (2001), Marjanovic (2000) and Ozcelik (2010) have failed to show how these factors interrelate and what effects the causal relationships have on overall BPC success. Furthermore, most of the studies that have examined the relationships in BPC projects have solely focused on one, or a few, specific causal relationships, e.g. the impact of IT or change management on BPC success which stands isolated, somewhat, within the context of BPC. Furthermore, prior research on relationships in BPC projects has focused on elaborating general relationships, thereby not capturing the complexity of a BPC venture (Trkman, 2010). Trkman (2010) further emphasizes the need to explain the complex interactions of various aspects inherent in BPC projects.

Challenge 3: *No clear understanding of the complex and dynamic interactions inherent in BPC projects*

BPC initiatives are seen as complex endeavors and their management is located in a highly complex and dynamic environment (Milling, 1996). The decisions are shaped by many dynamic and interacting factors that are difficult to predict. Milling (1996) argues that BPC projects involve numerous interactions inside the projects as well as interaction between the organization and its environment (Milling, 1996). Ashayeri, Keij, & Broeker (1998) assert that the complexity of decisions inherent in BPC projects have increased in two ways. First, the number of factors that influence the decisions in BPC projects has increased; i.e. detail complexity. Second, the importance of dynamic relationships inherent in BPC projects has increased; i.e. dynamic complexity. Due to the detail and dynamic complexity of the system under investigation there might be a time gap between action / decision and the evidence of its consequences (Milling, 1996). What is more, decisions have to be made very often under time constraints (Milling, 1996) or are affected by several uncertainty-causing elements, such as the allocation of human and IT resources, or socio-technological integration. Thus, decision-making in BPC projects is a very complex and risky task which cannot be performed manually (Ashayeri, Keij, & Broeker, 1998; Milling, 1996).

With the high failure rates in mind and as a result of the increased detail and dynamic complexity, a number of authors call for an approach that can support the BPC decision-making process (Milling, 1996; Trkman, 2010; van Ackere, Larsen, & Morecroft, 1993). A number of authors agreed that a simulation approach such as system dynamics (SD) would be able to cover the complexity and inherent dynamics of BPC projects (Akkermans & Dellaert, 2005; Ashayeri, Keij, & Broeker, 1998; K. G. Cooper & Reichelt, 2004; Howick & Eden, 2001; Lyneis, Cooper, & Els, 2001; Milling, 1996; Park & Pena-Mora, 2003). Such SD models can help decision-makers to better understand the dynamic consequences of actions without time and cost pressure or other resource constraints (Sterman, 2001).

Several authors thus showed the suitability of SD in the context of BPC projects (Ashayeri, Keij, & Broeker, 1998; Baguma & Ssewanyana, 2008; Burgess, 1998; Quaddus & Intrapairot, 2001; van Ackere, Larsen, & Morecroft, 1993). One of the early applications of SD in BPC was by van Ackere, Larsen, & Morecroft (1993). The authors adopted an SD simulation game, known as the “beer game” and analyzed the decisions of shipments and factory production to customer demand. They found that at the outset what had looked like a simple task was almost impossible to accomplish. Ashayeri, Keij, & Broeker (1998) studied the impact of restructuring processes in all functions based on customer value. They identified mutual relationships between criteria that were important to the customer (external criteria) and the performance measures for internal usage (internal criteria) in order to analyze the impact on the customer’s requirements and preferences. Burgess (1998) on the other hand, proposed an SD simulation model that was focused on competitive capabilities, such as quality, cost, time and flexibility and analyzed the benefits resulting from cost reduction. Another related approach is the work of Baguma & Ssewanyana (2008) who analyzed the impact of network infrastructure on overall BPC success. They found that network infrastructure is crucial when improving business processes and enhancing customer services.

It is not surprising that the majority of SD models in the BPC field are focused on particular behavioral aspects only. Moreover, these models vary widely in the level of detail provided. Yet, these models do not capture the complex and dynamic BPC behavior resulting from nonlinear structures such as rework or learning curves. Furthermore, they tend to overlook the emergent and complex interactions that are fundamental to any BPC initiative.

1.3 Research Questions

Accepting the challenges identified in the previous sub-chapter, then the overall objective of this thesis is to explore the dynamic complexities inherent in BPC projects by the development of a system dynamics simulation model that can be employed for managing and analyzing the dynamic complexities in BPC initiatives in the forefront of a possible implementation.

A central challenge of BPC is the identification of the impact factors influencing a successful BPC implementation. The BPC research field builds on a wealth of knowledge derived from a number of case studies (Jurisch, Wolf, & Krcmar, 2013) each of them providing valuable insights into past BPC project failures and successes (Grover & Markus, 2008; Grover et al., 1998; Guha et al., 1997; Huizing, Koster, & Bouman, 1997; Kettinger & Grover, 1995; Trkman, 2010). However, these case studies have remained relatively unexplored (Jurisch, 2014). We aim, therefore, to review and consolidate the abundance of BPC case studies in order to identify, empirically, the main impact factors of BPC. To achieve these objectives, we have formulated the following research question:

<u>RQ#1:</u> *What are the impact factors in BPC projects?*

BPC projects consist of many factors that interrelate in the sense that changes made to one of them influence all the others either directly or indirectly. To understand the dynamism and complexity inherent in BPC projects it is important to identify the relationships between the BPC impact factors. The main purpose is to determine the causal relationships instead of statistical correlations which do not necessarily indicate the cause and effect relationship but rather predict the impact of one variable on the other without proving it. However, the identification of one-way causal relationships is only the first step in dynamic model conceptualization (Barlas, 1996). The more important step is the identification of dynamic, circular causalities over time (Barlas, 1996) which can help to uncover the complexity of a the nature of a system. These causalities might be displayed in a causal loop diagram (CLD) which captures the causal influence among the variables and helps by enhancing the understanding of the dynamic behavior of studied phenomena (Flood & Jackson, 1991). We aim, therefore, to address the following research question:

<u>RQ#2:</u> *Which causal relationships can be identified between the BPC impact factors?*

Existing research on human behavior in dynamic feedback systems has revealed that human beings cannot sufficiently take into account dynamic and complex elements, such as lags, self-reinforcing feedback and hand effects and non-linear constraints (Kampmann, 1992). The results of their decisions are therefore very far from optimal (Kampmann, 1992). The greatest advantage of SD simulation, in comparison with the human way of thinking and decision making, is that it can cover the complexity, feedback structure and hand effects and non-linearity (Forrester, 1994b). In particular the use of feedback loops distinguishes SD from other approaches of studying complex systems (Wessely, 2010). SD models can be simulated and, as a result, the effect of differences in interventions, timing, delays and feedback can be observed immediately (Wessely, 2010). Thus, SD simulation can be used in complex and dynamic settings; i.e. in contexts where analytical solutions are too complex or not known (Madachy, 2008). SD can be helpful in identifying key decision-factors and the interrelationships between them and so help to perform decisions in a more efficient way by visualizing and interactively analyzing the model over multiple scenarios (Sterman, 2001). In particular, we will address the following research question:

RQ#3: *What benefits and limitations can be observed from the application of the system dynamics simulation model to BPC projects?*

1.4 Structure

This cumulative thesis consists of three main parts. Part A consists of three chapters and gives an overview of this doctoral thesis. The first chapter in part A motivates this research by outlining the problem statement, proposes the research objectives and shortly summarizes the structure of this thesis. The second chapter in part A provides the conceptual background for this thesis and introduces the concepts of business process change (BPC), complex systems and the application of SD in the decision-making process. The third chapter in part A outlines the overall research strategy and describes the applied research methods. Part B consists of seven peer-reviewed publications which aim to answer the aforementioned research questions. All publications have been published in double-blind peer reviewed conferences and double-blind peer reviewed journals. Part C concludes this thesis by summarizing and discussing the results of the embedded publications. It further summarizes the limitations of this study and discusses the implications for research and practice. Finally it illustrates some avenues for future research. The structure of this thesis is summarized in Figure 1.

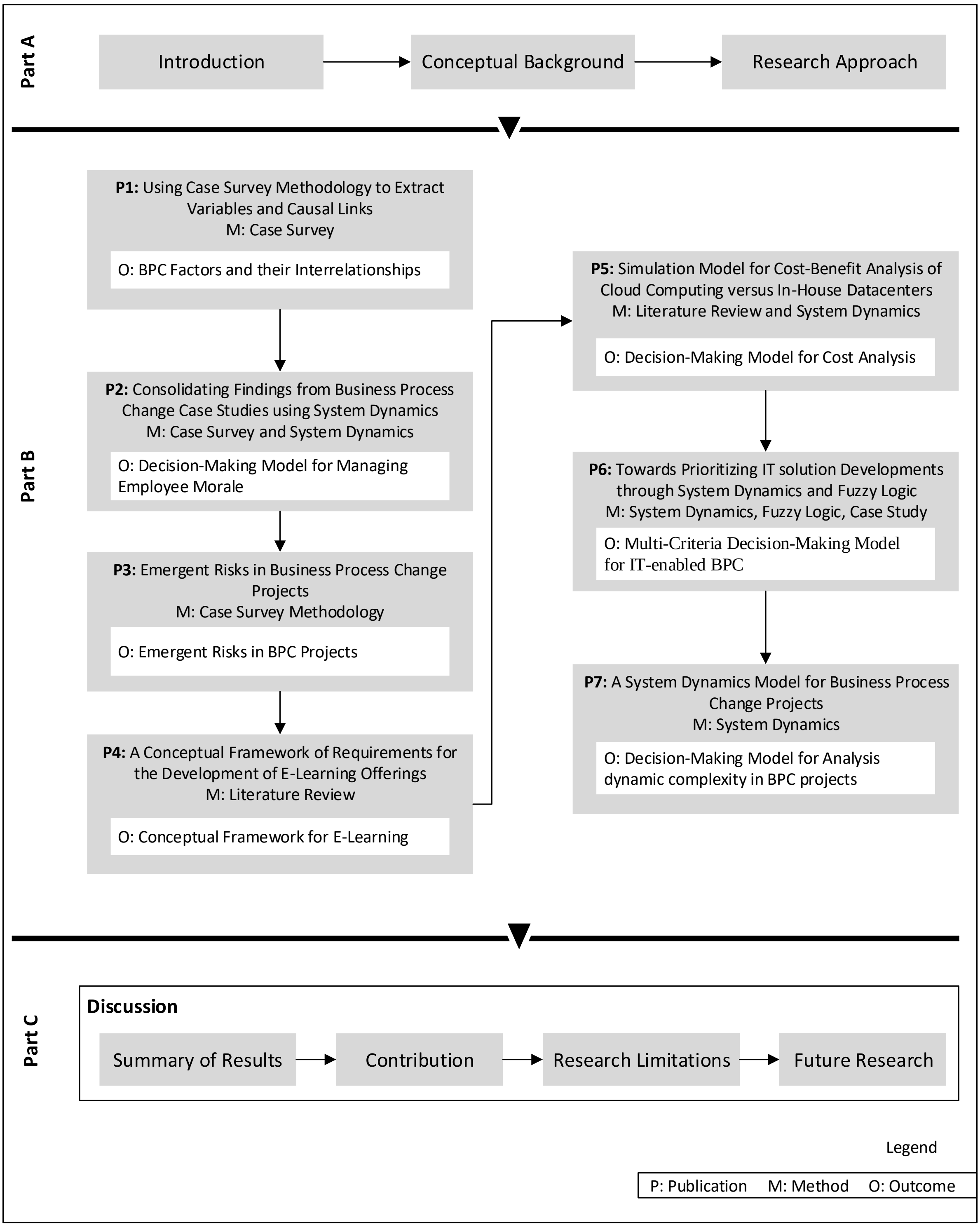

Figure 1. Thesis structure

In the following, the seven publications embedded in part B are briefly summarized (see Table 1). The summary of each publication (P) outlines the research problem, the methodological approach and the main contributions.

- **P1: Using Case-Survey Methodology to Extract Variables and Causal Links.** This publication integrates the fragmented research on BPC in order to obtain a coherent picture of the impact factors and their causal links. We applied the case-survey methodology to extract the impact variables and causal links within BPC projects. We encapsulated the insights of 130 case studies which reported past BPC project experiences in a way that is concise, meaningful and helpful to researchers. We coded 458 dependent variables, 1621 independent variables and 852 relationships between dependent and independent variables. As a means of demonstration and exploration, we designed a causal loop model that captures the identified impact variables and the corresponding relationships. This publication provides empirical evidence on impact factors and their relationships in BPC projects and shows that system dynamics is a suitable method for complex systems such as BPC.

- **P2: Managing Employee Morale in BPC Projects.** BPC projects represent a complex phenomenon that is characterized by many uncertainties, frequent delays or even failures. Consequently, there is a great need to train practitioners to manage these complexities successfully. Until today no learning offering exists that can help managers to fully comprehend the important parameters in BPC projects and their impact on project success. Some researchers have argued that through the use of learning offerings based on SD, decision-makers will be able to understand and control the important parameters and complex feedback loops in BPC projects. Therefore, this publication investigates the benefits of SD in the context of BPC. Based on the data from 65 case studies, we applied the concept of SD to derive a simulation model geared towards the exemplary central variable "employee morale". Our findings indicate that employee morale has a significant impact on overall BPC project success. From a more general perspective we simultaneously demonstrated the capability of SD for eliciting impact factors on project success as well as their relevant relationships within BPC projects. The contribution of our research is twofold: We introduce and evaluate SD as a method for generating and conveying knowledge concerning the dynamic effects of relevant impact factors within BPC projects. Secondly, we propose a simulation model enabling practitioners to analyze and understand different policy changes and their consequences before implementing them in an actual project. We posit that this, and similarly derived models, harbor great potential for fostering awareness among project members and subsequently improving BPC success rates.

- **P3: Emergent Risks in Business Process Change Projects.** Even today still many BPC initiatives fail and cause high overruns. However, most organizations no longer have the luxury of funding BPC projects that may not succeed. It is therefore important that BPC practitioners understand the risks inherent in BPC projects and that they adapt their risk management processes to account for, and mitigate, these risks. Thus, this paper investigates the impact of emergent risks on BPC projects and process performance using a temporal model of IT project performance. We adopted a case survey method and investigated data from 130 case studies in order to show the nature and magnitude of relationships between organizational support risks, volatility risks and BPC project and process performance. Our results show that organizational support risks have a stronger influence on the overall BPC project performance, whereas governance volatility shows only a significant influence on BPC project performance. These results extend prior research on BPC by identifying emergent risks and their impact on BPC project and process performance.

- **P4: A Conceptual Framework of Requirements for the Development of E-Learning Offerings.** The purpose of this research was to provide an understanding of successful development and operation of an e-learning offering. For this purpose, this research analyzes 23 articles dealing with e-learning offerings. The outcome of the literature review is a five-part conceptual framework consisting of project, teaching, functionality, lifecycle and, the level of, service requirements. These are derived from literature on product service systems (PSS), hardware, software and services. The proposed framework was validated by 65 students with management and information systems background and business backgrounds. This paper contributes a novel, single expression of the requirements for e-learning offerings based on a lifecycle perspective using aspects of multiple design, development and operations at the same time. From a practical perspective, the proposed framework might be used in collaborative requirements workshops and other settings. From a research perspective, the framework might be used as a starting point for the development of e-learning requirements engineering models adopting a systems approach.

- **P5: Simulation Model for Cost-Benefit Analysis.** This paper proposes a simulation model for cost-benefit analysis of cloud-computing versus the operation of an in-house datacenter. Several models exist that support organizations by analyzing the costs that result from offering own services in the cloud as against the costs caused by an in-house datacenter. These are, however, mainly static and do not consider the dynamics of cost development. Thus, this publication proposes a system dynamics based simulation model that covers the dynamic aspects of cloud computing. The model variables and their quantifications were identified in the literature where we analyzed the costs, risks, advantages and disadvantages inherent in both domains. Six decision-makers applied the proposed simulation model for analyzing the cost-benefits between cloud computing and an in-house datacenter. They tested different scenarios and found, from the outset, that the simulation model was useful, intuitive and complete. From a practical perspective, the simulation model could be used virtually to analyze different scenarios. From a research perspective the simulation model could be used for testing different types of hypotheses and deriving recommendations for further actions.

- **P6: Prioritizing IT-Solution Developments through System Dynamics and Fuzzy Logic**. This paper proposes an integrated multi-criteria decision-making model to effectively handle decision-makers' subjectivity and uncertainty in IT-enabled BPC. It applies a fuzzy logic approach to integrate qualitative interview data into multi-criteria decision models and system dynamics simulation to integrate dynamic variables. Based on a case study made by a mid-sized German organization we demonstrate the usefulness of such decision-making models by providing robust analyses for the selection of IT-solutions by reconciling the perceived subjectivity and uncertainty. This publication presents a novel approach to overcome the "fuzziness" in traditional IT-solution selection processes by using fuzzy logic and system dynamics. It can help practitioners prioritize IT-solution rankings and make optimal decisions regarding its development and integration.

- **P7: System Dynamics Model for Business Process Change Projects.** BPC initiatives are characterized as complex initiatives with many dynamic and interacting factors whose outcomes may be difficult to predict. For the overall success of BPC, practitioners and researchers need to understand the outcomes of various BPC decisions resulting from the many cause-and-effect relationships. Thus, the purpose of this research is to support decision-makers by analyzing and managing the outcomes of complex relationships inherent in BPC projects. For this purpose, we proposed an SD simulation model that conveys the complex relationships between important constructs in BPC. The resulting model is based on results compiled from 130 case studies reporting the success and failure of BPC projects. BPC researchers can use the proposed model as a starting point for analyzing and understanding BPC decisions under different policy changes. Practitioners will obtain a ready-to-use simulation model to be used in to make various BPC decisions. Furthermore, the resulting model provides considerable support for determining which factors can be leveraged when implementing BPC since it enables the decision-makers to see the results of previous decisions and thereby decide how to proceed.

No.	Authors	Title	Outlet	Type
P1	Rosenberg, Jurisch, Schermann, Krcmar	Using Case Survey Methodology to Extract Variables and Causal Links: An Example from Studying Business Process Change	International Conference of the System Dynamics Society 2014 (**ICSDS**) (accepted)	CON (NR)
P2	Kristekova, Jurisch, Schermann, Krcmar	Consolidating Findings from Business Process Change Case Studies using System Dynamics: The Example of Employee Morale	Knowledge Management & E-Learning: An International Journal 2012 (**KMELIJ**) (accepted)	JNL (NR)
P3	Jurisch, Rosenberg, Krcmar	Emergent Risks in Business Process Change Projects	Business Process Management Journal 2015 (**BPMJ**) (accepted)	JNL (WKWI: B)
P4	Herzfeldt, Kristekova, Schermann, Krcmar	A Conceptual Framework of requirements for the Development of E-Learning Offerings from a Product Service System Perspective	Americas Conference on Information Systems 2011 (**AMCIS**)	CON (WKWI: B)
P5	Kristekova*, Brion, Schermann, Krcmar	Simulation Model for Cost-Benefit Analysis of Cloud Computing versus In-House Datacenters	Multikonferenz Wirtschaftsinformatik 2012 (**MKWI**) (accepted)	CON (WKWI: C)
P6	Kristekova, Riasanow, Schermann, Krcmar	Towards Prioritizing IT Solution Developments through System Dynamics and Fuzzy Logic	Hawaii International Conference on Systems Science 2012 (**HICSS**) (accepted)	CON (WKWI: B)
P7	Rosenberg, Riasanow, Krcmar	A System Dynamics Model for Business Process Change Projects	International Conference of the System Dynamics Society 2015 (**ICSDS**) (accepted)	CON (NR)

- Surname at birth; JNL: Journal; CON: Conference; NR: Not Ranked; WKWI: Research Commission for Information Systems Research

Table 1. Overview on embedded publications

2 Conceptual Background

The following chapter introduces three main streams of research which provided the conceptual background for this thesis: research on BPC, research on complex systems and research on decision-making processes. The first subchapter defines the term BPC and other major terms, connected to the BPC domain, as well as explaining its central elements. The second subchapter exposes the nature of complex systems and shows how people learn about complex systems. The last subsection explains the concepts of decision-making processes and shows how SD-based decision support systems can be applied within the overall context of decision-making in, and about, complex systems.

2.1 Business Process Change

BPC has a 25-year track record of evolution. It also has its roots in Business Process Reengineering (BPR), even when Michael Hammer's "Reengineering Work: Don't Automate, Obliterate" (Hammer, 1990) and Thomas Davenport and James Shorts' "The New Industrial Engineering: Information Technology and Business Process Redesign" (1990) insisted that companies must think in terms of comprehensive processes and concentrate on core processes. Such process-oriented organization changes the structural relationships between management and employees into interactive processes (Chen, 2001). Usually management assigns targets in terms of work performance and departments work together to achieve these targets. This direct path for coordination leads to a streamlined and efficient workflow (Chen, 2001). Such organizations generally achieve a higher level of performance than functionally oriented organizations. Functionally oriented organizations highlight the hierarchical structure of the organizational units responsible for particular functions. Such organizations separate processes into smaller tasks that might be performed by each employee with little responsibility (Chen, 2001). Under this structure, the most important decisions are forwarded to, and made by, the higher skilled, and more trusted, managers (Chen, 2001). This enhances performance on a functional level but leads to poor integration between functions. Each functionally oriented department optimizes its function independently which causes difficulty in the coordination between departments. As a result, departments strive to achieve their targets without taking the targets of other departments into consideration. When one department fails to achieve its target it has an effect on the whole organization.

In the 1990s radical change, such as BPR, was the dominant subject. However, the focus of reengineering processes was shifted later to the importance of processes[3] instead of the radicalness of the change (Grover, Kettinger, & Teng, 2000; Grover & Kettinger, 1997, 2000; Kettinger, Teng, & Guha, 1997). Over the years BPC has been confounded with a number of terms with similar, though not necessarily identical, meanings (e.g., business process reengineering (BPR), business process transformation (BPT) or business process improvement (BPI)) (Sarker, Sarker, & Sidorova, 2006).

[3] We use the term "process" as a short form of "business process". For the purposes of this thesis, we adopted the definition by Davenport & Short (1990) who defined business process: "*as a set of logically-related tasks performed to achieve a defined business outcome*".

BPC refers to a management concept that involves any type of process change – revolutionary/radical or evolutionary/continuous (Grover, Kettinger, & Teng, 2000; Grover & Markus, 2008) as well as quality programs, enterprise resource planning (ERP) implementations or the retooling of business processes for e-commerce (Sarker, Sarker, & Sidorova, 2006). While both approaches, radical (e.g., BPR, BPT) and continuous (e.g., total quality management (TQM), continuous process improvement (CPI), six sigma), share the common goal of improving processes, they are also frequently used complementarily (Grover & Markus, 2008). In the following, we define the major terms connected to the domain of BPC.

Revolutionary change

Much of the current interest from industries and the academic community in revolutionary change can be dated to 1993 when (Hammer & Champy, 1993) first mentioned the term BPR in their seminal work: "Reengineering the Corporation - A Manifesto for Business Revolution". A BPR approach aims to fundamentally rethink and radically redesign the essential business processes of an organization to achieve improvements in important and measurable performance indicators such as costs, quality of products and services, or time (Hammer & Champy, 1993). The word *fundamentally* implies that processes need to be redefined regardless of the current processes whereas the word *radically* indicates a clear dividing-line to the past and not to the improvement of the existing processes. BPR concentrates on major, discrete changes to business processes and the results are not small and incremental but are rather very large and far-reaching (radical/revolutionary) enhancements which go beyond the current structures of an organization. The result is the replacement of existing process structures by fundamental and innovative solutions in order to achieve radical improvements in process performance (see Figure 2). This further involves going back to the beginning and inventing a better way of doing work (Hammer & Champy, 1993).

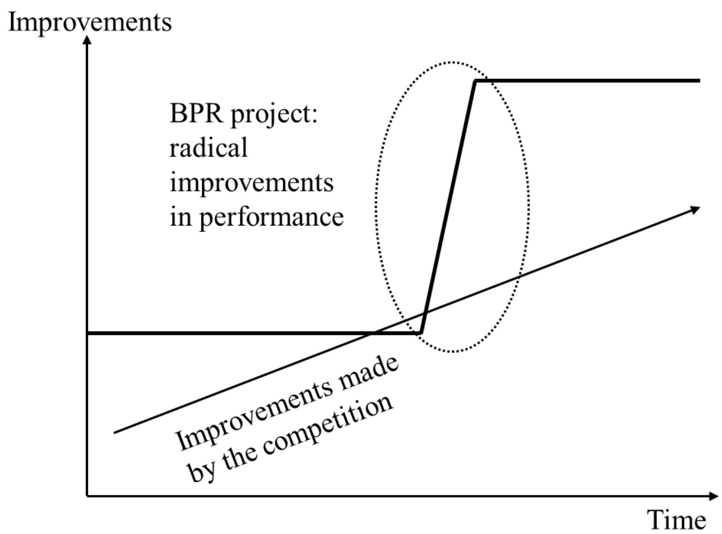

Figure 2. BPR requires radical improvements in performance (Adapted from Riasanow 2015)

The major activities of BPR are: (1) to break the current business processes and (2) conceive new ways of organizing tasks, organizing people and making use of IT systems (Vidgen et al., 1994).

These activities are done by identifying critical business processes, analyzing these processes and redesigning them for efficient improvement and benefit. Vidgen et al. (1994) argue that BPR should include following central tenets:

- Radical change and assumption challenge,
- Process and goal orientation,
- Organizational re-structuring,
- The exploitation of enabling technologies, particularly information technology.

BPR is commonly viewed as a top-down solution from management (Stewart, 1993). Stewart (1993) argues that BPR cannot be led from the bottom of organizations since it may be blocked by organizational boundaries. Paper et al. (2001) enhanced this view by arguing that BPR not only necessitates top management support but also bottom-up employee empowerment. Otherwise, the neglect of employees may be one of the major reasons for BPR failure.

BPT and BPI are frequently used as synonyms for the same subject (Grover & Markus, 2008) who analyzed the characteristics of these approaches and came to the conclusion that they can be interpreted as following a bandwagon effect in the literature of revolutionary change approaches. In summary, all BPR, BPT and BPI concepts are radical, revolutionary and one-time undertakings (Davenport, 1993; Grover, Kettinger, & Teng, 2000; Grover & Markus, 2008).

Evolutionary change

Total Quality Management (TQM) is considered as an integrative management concept (Zink, 2004). More specifically, TQM is viewed as a more evolutionary and continuous concept to constantly optimize and change business processes (Bucher & Winter, 2007). Dale (1994) defines TQM as "*the mutual co-operation in an organization and associated business processes to produce value-for-money products and services which meet, hopefully and exceed the needs and expectations of customers*". According to Dale (1994) satisfied customers and understanding their needs are key points in successful TQM. Furthermore, TQM aims at improving the quality of products and services in all departments and functions (Koch, 2011) and controls all transformation processes of an organization to satisfy customers' needs better in the most economical way (Talha, 2004). Figure 3 shows the continuous process of TQM.

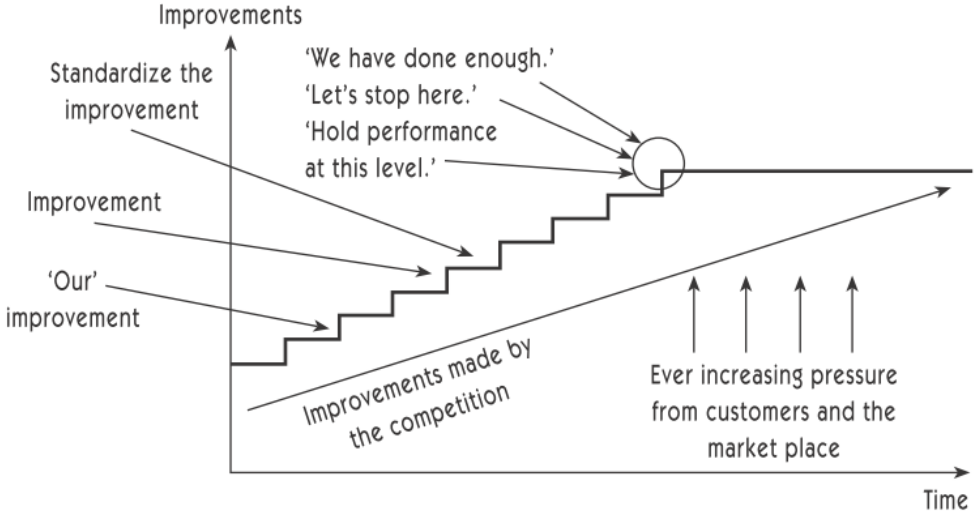

Figure 3. TQM quality improvement: a continuous process
(Adapted from Dale 1994)

If an organization claims that it has achieved improvements involved in TQM and afterwards stops the continuous improvement, it might be overtaken by the competition (Dale, 1994).

Both approaches BPR and TQM share the common goal of improving business processes, however they are quite different in regard to objectives, methods, results and business circumstances (Butler, 1994). TQM, in contrast to BPR, concentrates on minor continuous improvements to business processes. Butler (1994) explains the difference between BPR and TQM as: "*TQM approach which favors steady incremental gain, may often take a number of years to complete. For firms in highly competitive industries, this lag time can allow competitors to forge ahead*".

TQM involves employees from all levels of the organization for problem solving and bottom-up improvement suggestions. Pushing problem solving and decision-making down in the organization allows all employees to both measure and to take corrective actions in order to deliver a product or service that meets the needs of their customers better (Talha, 2004). Thus, TQM and the corresponding bottom-up involvement of employees face less resistance to change then BPR initiatives (MacIntosh & Francis, 1997).

TQM consists of different concepts for continuous process change. Two prominent concepts are Kaizen and Six Sigma. Kaizen is the Japanese word for continuous process improvement that is applied to existing products and services. Kaizen can be translated into Kai = Change + Zen = Good (Autorenteam, 1994). Various researchers emphasize different key features, but many focus on three key notions (Brunet & New, 2003):

- Kaizen is continuous – which indicates the embedded nature of the practice and also its place in an ongoing journey towards quality and efficiency;
- Kaizen is incremental in nature – in contrast to major management initiated reorganizations or technological innovation (e.g. the installation of new technology or machinery);

- Kaizen is participative – entailing the involvement and intelligence of the employees, generating intrinsic psychological and quality of work-life benefits for the employees.

Suárez-Barraza and Lingham (2008) summarize Kaizen as a method that involves all the employees of the organization, implements small and incremental improvements and uses teams as the vehicle for achieving incremental changes.

The second prominent TQM method, Six Sigma, is viewed as a more continuous organizational change and improvement method (Sidorova & Isik, 2010). Although originally introduced by Motorola in 1986 as a quality performance measurement, Six Sigma has evolved into a statistically oriented approach (Coronado & Antony, 2002). It uses powerful statistical tools and techniques to identify problems and involves the designing, improving and monitoring of business processes with the goal of reducing costs and enhancing throughput times (Nave, 2002; Revere, Black, & Huq, 2004).

2.2 Complex and Dynamic Systems

Since the World War I, the topic of complex and dynamic systems has gained attention among scientists in such diverse research fields as chaos theories, cybernetics, theories of holism and general system theory (Simon, 1996). This multidisciplinary field makes it difficult to find a universally accepted definition for the term "complex and dynamic systems". We have adopted the definition proposed by Simon (1996), who explains a complex and dynamic system as "*one made up of a large number of parts that have many interactions*".

Several researchers (Dorner, 1996; Jacobson & Wilensky, 2006; Senge, 2006) reported that primarily human beings think in events or limited linear causal structures and that they underestimate, or ignore, complex and dynamic behavior of studied phenomena. This inability to understand the complexity and dynamics of systems primarily arises: (1) due to the limitations of our mental models which are internally inconsistent and unreliable and (2) as a result of the poor ability to understand the unfolding impacts of our decisions (Sterman, 2001). "Mental model" is a repeatedly used term for the cognitive structures of individuals with internal, deduced representations complementing the use of logic and affecting the way humans make inferences (Johnson-Laird, 1986). Additionally, the heuristics we use to judge causal relationships systematically lead to cognitive maps that ignore feedbacks, nonlinearities, time delays and other elements of systems complexity (Sterman, 2001). As a consequence, decision-makers are biased in their judgements of decision-strategies since they do not account for hand effects, self-reinforcing dynamics and delays in the system (Bakken, 1993; Kampmann, 1992). An interesting aspect of mental models or cognitive maps is that people seek confirmation for their theories rather than questioning them. As a consequence they often remain in severely sub-optimal decision and problem solving strategies (Bakken, 1993). This is in line with Sterman (2001) who reported that decision-makers tend to assume each event has a single cause and often discontinue their search for explanations when the first sufficient cause is found.

Sterman (2001) further reported that human beings mainly use: (1) temporal and spatial proximity of cause and effect, (2) temporal precedence of causes; i.e. that cause happened before the effect, (3) covariation and (4) the similarity of cause and effect. However, in complex and dynamic systems, cause and effect are often distant in time and space (Sterman, 2001). This means that the consequences of our actions are delayed and distant and different to their proximate effects or are simply unknown (Sterman, 2001). Other researchers (Resnick & Wilensky, 1993; Wilensky & Resnick, 1995, 1999) reported that decision-makers tend to prefer explanations that assume deterministic causality. I.e. that any event is completely determined by antecedent events. E.g. if "A" causes "B" then "A" must always be followed by "B". Gleick (1987) and Lorenz (1963) further reported that many people assume a linear relationship between their action and its corresponding effect. However, in complex and dynamic systems a small action can significantly contribute to a large-scale effect in the system (Gleick, 1987; Lorenz, 1963). The result is policy resistance. The policy resistance arises when policy actions trigger feedback from the environment that undermines the policy and at times even exacerbates the original problem (Forrester, 1971). Policy resistance is common in complex and dynamic systems with many feedback loops and long delays between policy action and result (Sterman, 2001). In such systems learning is difficult and decision-makers may continually fail to estimate the full complexity and dynamics of the systems that they are attempting to influence (Sterman, 2001).

Several studies in different fields confirm these assumptions about the cognitive challenges to understanding the systems' complexity and dynamics. For example, Sterman (1989) showed that a significant number of students and managers involved in the production-distribution game, or "beer game", had difficulties in solving the task of minimizing the costs by managing inventory levels in a production-distribution chain. Sterman (1989) concludes that many participants fail to adequately account for the effects of delays and have great difficulties appreciating the feedback between their own decisions and the environment. Even when provided with perfect information and knowledge of the system structure. Other experiments yielded similar results, as reported by Dorner (1996). He observed students and professionals participating in different simulations and concluded that the majority of participants could not solve simple tasks involving dynamic thinking. Dorner (1996) believes that these poor results are due primarily to a lack of system understanding and tendencies to focus on short term effects rather than more long-term and fundamental processes (Dorner, 1996). This finding is consistent with Sterman (2001) who argues that due to our imperfect appreciation of complexity, the decisions we are making often hurt us in the long run.

A number of researchers (Doyle & Ford, 1998; Jacobson & Wilensky, 2006; Wang & Chen, 2012) argue that while analyzing a decision, decision-makers scan their memory for similar situations by using their cognition to capture current reality and mentally predict the future state according to available alternatives. Jacobson and Wilensky (2006) thus conclude that decision-makers should build on their experiences and knowledge to construct beliefs about how things behave. Jacobson reported in several studies (Jacobson, 2000, 2001) that there are significant differences between individuals with complex and dynamic systems expertise and novices. He found that complex systems experts possess specialized conceptual understandings that novices do not possess and that novices and experts use different ontologies when developing solutions to problems of complex and dynamic systems. In detail, Jacobson (2000, 2001) found in his experiments with undergraduate students who were novices to complex and dynamic systems that they were using a set of "clockwork" ontological statements. These statements referred to the control of a system from a centralized source. On the other hand other experts used a set of "complex and dynamic systems" ontological statements in which system control emerged as part of the decentralized interactions of elements (Jacobson, 2000, 2001). The research on expert and novice differences provides strong support for these findings (Chi, Glaser, & Farr, 1988; Council, 2000; Larkin et al., 1980). Alternatively, conceptual change theories show how cognitive structures such as ontological and epistemological beliefs strongly afford or constrain the ability of a decision-maker to understand particular types of a complex and dynamic system (Chi, 1992, 2005; diSessa, 1993; Vosniadou & Brewer, 1992, 1994).

Researchers, therefore, emphasize that decision-makers need opportunities to experience the phenomena of complex and dynamic systems in ways that will let them enhance both their ontological and conceptual understandings (Jacobson & Wilensky, 2006; Senge & Sterman, 1992; Sterman, 2001). One way to gain experience in complex and dynamic systems is through Systems Thinking. Systems Thinking is a discipline where people learn to understand interdependency and change better and thereby deal more effectively with the forces that shape the consequences of their actions (Senge, 2006). The basic concepts of Systems Thinking are stocks and flows, time delays and negative feedback (Senge, 2006) which are also concepts used in the SD methodology. Several definitions of Systems Thinking have evolved over time and have been controversially discussed and compared with SD (for more information see Richmond (1994)).

With the help of SD, decision-makers learn to understand the complex and dynamic phenomena in an effective way by looking at connected entities rather than separate parts. This means that instead of isolating smaller parts of the system (which is the case in traditional analysis), SD works by expanding its view and takes into account larger and larger numbers of interactions while studying an issue. According to Sweeney and Sterman (2000) SD should support decision-makers by:

- Understanding how the behavior of a system arises from the interaction of its components over time (i.e., dynamic complexity),
- Discovering and representing feedback processes (both positive and negative) hypothesized to underlie observed patterns of system behavior,
- Identifying stock and flow relationships,
- Recognizing delays and understand their impact,
- Identifying nonlinearities and
- Recognizing and challenging the boundaries of mental (and formal) models.

Senge (2006) further argued that learning is not an individual behavioral attribute but a shared, cognitive learning process that might change organizations by modifying the decision-makers' mental models (Senge, 2006). Improving mental models is the ongoing, open-ended process of explicating, testing and revising managerial assumptions (Senge & Sterman, 1992). Once decision-makers reveal their mental models they can begin to discover internal inconsistencies and contradictions with the data and others' knowledge. Decision-makers who adopt SD in their organizations find leverage solutions for organizational problems, develop strategic plans for organizational sustainability and improve their overall organizational learning skills (Senge, 2006). Even though a group of individuals adopting SD does not guarantee organizational learning, SD has been identified as an effective means of helping organizations in following a correct learning path (Senge, 2006). On the other hand, a group of decision-makers, who are willing to establish mutual trust, commit themselves to team-learning, understanding organizational visions and exploring personal mental models (Senge, 2006). This can clearly enhance organizational learning.

Several researchers support Senge's (2006) claim and argue that the problematic nature of learning as an intentional action might be resolved by shifting it from the individual to the organization-level as a shared cognitive construct that identifies practice with learning (Marshall, 2008; Ortenblad, 2002; Weick, 1991). Senge (2006) treats learning as a process guided by practices (learning by doing), rather than theoretical knowledge, and concludes that theoretical knowledge is not learning unless it is transformed into practice.

Several researchers propose to use SD simulations as “learning laboratories” where decision-makers might immerse themselves in different roles within a simulated organization. (Senge & Sterman, 1992). These learning laboratories, or micro-worlds, might be compared to an aircraft simulator for pilots where the pilots try different strategies in a wide range of conditions without risk. Such learning laboratories save time and allow decision-makers to experience the long-term, system-wide consequences of decisions (Graham et al., 1989; Sterman, 1988). Bakken (1993) reported that learning laboratories have shown better results in transferring knowledge than case studies and lectures. This might also be attributed to the motivational hands-on effects of the interactive pedagogy (Bakken, 1993). According to Senge & Sterman (1992) an effective learning laboratory is more than just a computer simulation. It trains decision-makers to develop skills such as articulating hypotheses and reflecting on the outcomes of actions to prove or disprove their hypotheses (Hogart, 1987). The outcome is a higher awareness of the assumptions underlying policies and strategies, better systems thinking skills, shared understanding of complex and dynamic issues and enhanced individual and group learning skills (Senge & Sterman, 1992).

2.3 Application of System Dynamics in the Decision-Making Process

Decision-making is a fundamental activity for managers and is seen as “the essence of the manager’s job” and as “a critical element of organizational life” (Robbins, 1999). Marquez and Blanchar (2006) define a decision-making process as a matter of reasoning (using the mental models of the manager) and analogizing (based on stories about similar events retained in memory). A number of authors argue that the decision-making process should be supported by a rigorous approach that is capable of capturing interrelationships among variables and in handling dynamic aspects of the system behavior (Akkermans & Dellaert, 2005; Gray et al., 2008; Morrison, 2012; Pierson & Sterman, 2013). Thus, over the years a number of distinct approaches for supporting and enhancing decision-making processes have evolved, such as intelligent, knowledge management-based and system dynamics-based decision support systems (SDDSS). For the purpose of this thesis, we will focus only on SDDSS.

SDDSS has been an important research topic for many decades and much effort has been made in this domain. Especially in how to design, develop and implement effective SDDSS. Economists, psychologists, operation researchers and management scientists have investigated this topic from their various perspectives (Power & Sharda, 2007). Research in this area has typically focused on how IT can improve the efficiency with which a user makes a decision and how the effectiveness of that decision can be improved (Pearson & Shim, 1995).

SDDSS has its roots in two main areas of research: (1) the theoretical studies of organizational decision-making and (2) the technical work. The first area of SDDSS research has been unequivocally associated with Herbert Simon who was a key researcher into the contributions to organizational decision-making. Especially his further work with James March. The second area of SDDSS research was carried out at Massachusetts Institute of Technology in the 1960s (Keen & Morton, 1978) and is associated with Gorry & Morton (1971). Gorry and Morton (1971) defined SDDSS in a broader manner by combining Anthony's (1965) definition of management activity and Simon's (1960) description of decision types and decision-making processes. Anthony (1965) defined management activity as a process consisting of three main steps: (1) strategic planning (management decisions regarding the organization's mission and goals), (2) management control (middle management guiding the organization towards its goals) and (3) operational control (specific tasks). Simon (1960) distinguished between structured (i.e. programmed decisions), unstructured (i.e. non-programmed, based on human intuition) and semi-structured decision types. Simon (1960) proposed three steps for a decision-making process: (1) intelligence which is comprised of identifying problems, (2) design, which involves the development of alternatives and (3) choice, which consists of analyzing the alternatives and choosing one for implementation. Gorry and Morton (1971) defined SDDSS as a computer system that dealt with a problem where at least some stage was semi-structured or unstructured.

A number of researchers have reported a positive impact of SDDSS on decision-making processes (Arnott & Pervan, 2008; Gregor, 2002; Todd & Benbasat, 1991; Van Bruggen, Smidts, & Wierenga, 1998). For instance Arnott and Pervan (2008) and van Bruggen et al. (1998) observed an increase in the number of decision alternatives, more quality time spent on decision-making, increased confidence on the part of decision-makers and improved decisions.

Due to its numerous advantages, SDDSS has been applied in multiple research contexts, as indicated in Table 2.

Application Area	Sources
Change Management	(Babio, 2011; Dhawan, O'Connor, & Bormann, 2011; Harich, 2010; Lychkina & Shults, 2009; Quaddus & Intrapairot, 2001; Wunderlich et al., 2014)
Product Investment and Marketing	(Bivona & Montemaggiore, 2010; Briano et al., 2010; Loebbecke & Bui, 1996; Marquez & Blanchar, 2006; Rabelo, Helal, Jones, & Min, 2005; Walther et al., 2010)
Supply Chain Management	(Akkermans & Dellaert, 2005; Anderson Jr, Morrice, & Lundeen, 2005; Goncalves, Hines, & Sterman, 2005; Saeed, 2009; Shang et al., 2007)
Strategic Management	(Clark Jr. & Jones, 2008; Gray et al., 2008; Kunc, 2012; Legna & González, 2006; Mora et al., 2002; Morecroft, 1988; Paich, Peck, & Valant, 2011; Schmid et al., 2012; Škraba, Kljajić, & Leskovar, 2003; Weil, 2007; Yim et al., 2004)

Project Management	(Gößler, 2007; Kanungo & Jain, 2008; Luna-Reyes et al., 2008; Lyneis & Ford, 2007; Rahmandad & Weiss, 2009; Sahaf et al., 2014)
Innovation Management	(Bayer, Barlow, & Curry, 2007; Black, 2013; Maier, 1998; Milling, 2002; Tu, Wang, & Tseng, 2009)
Risk Management	(Dutta & Roy, 2008; Feola, Gallati, & Binder, 2012; Owens, Leveson, & Hoffman, 2011; Tan, Anderson Jr, Dyer, & Parker, 2010; Taylor et al., 2011)
Finance	(Forrester, 2013; Ghaffarzadegan & Tajrishi, 2010; Hayward & Boswell, 2014; Jung & Strohhecker, 2009; Pierson & Sterman, 2013; Singh & Bhar, 2014)
BPC	(Ashayeri, Keij, & Broeker, 1998; Bianchi & Montemaggiore, 2008; Eskinasi, Rouwette, & Vennix, 2009; Kunc, 2008; Morrison, 2012; van Ackere, Larsen, & Morecroft, 1993)

Table 2. Application areas of SDDSS

Surveying the articles, we found that literature provides a range of examples that make use of SDDSS in supporting and enhancing the decision-making process. This applies especially to the adjacent area of BPC. Change management, supply chain management and project management seem to realize the positive effects of SDDSS on the decision-making process. The domain of BPC still suffers from prevalent use. Only a small number of authors proposed SDDSS for decision-making process in BPC projects. However, these models vary widely in the level of detail provided and their structure. Also, in our review, we did not find that SDDSS could help practitioners adequately in fully comprehending the important parameters of BPC projects that are founded upon empirical data.

3 Research Approach

The following chapter discusses the research strategy and research methods used to answer the research questions. The first subchapter outlines the research strategy and the modeling process which was employed to answer the aforementioned research questions. The second subchapter introduces the research methods used in this thesis.

3.1 Research Strategy

The research in this thesis followed a mixed-methods research strategy. Since, BPC is a complex phenomenon, often with conflicting results and few reliable generalizations, a mixed-methods research strategy is suitable to achieve the objectives of our thesis's: Namely, exploring the BPC project's system and behavior by simulating the dynamic complexities inherent in such BPC projects. A mixed-methods research strategy combines both quantitative and qualitative approaches. For our research, we adopted the definition by Johnson, Onwuegbuzie, & Turner (2007), who settled upon the following definition for mixed-methods research strategy:

"*Mixed-methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration*" (Johnson, Onwuegbuzie, & Turner, 2007).

From our, rather pragmatic, perspective this definition works as a mixed-methods research strategy often requires a pragmatic, "wide-angle lens" viewpoint utilizing all data sources available to answer practical questions (Creswell, 2010). This pragmatic position stresses the importance of the problem rather than the importance of the methods (Creswell & Clark, 2011). Such a pragmatic perspective can help researchers understand how different research approaches can be combined successfully (Creswell, 2014).

A key feature of a mixed-methods research strategy is, on one hand, the possibility of data triangulation while studying the same aspects of a research problem and, on the other hand, the complementarity of both qualitative and quantitative data (Hesse-Biber, 2010). While triangulation strengthens and enriches the results of a study in a way that a single form of data might not permit (Hanson et al., 2005), complementarity allows for more complex generalizations by gaining a deeper understanding of a social phenomenon (Hanson et al., 2005; Hesse-Biber, 2010).

For the purposes of this study, we selected an exploratory sequential mixed-methods design as a result the following criteria: (1) exploratory sequential design is useful when a researcher first begins by exploring with qualitative data and analysis and (2) then uses the findings in a second quantitative phase. I.e. the second phase in the sequential design builds on the results achieved in the initial phase (Creswell, 2014). The purpose of exploratory sequential mixed-methods design is to investigate a set of research questions that all advance one research objective (Creswell, 2014).

In the first qualitative phase, we primarily used the case survey analysis and qualitative SD as our methods for collecting and exploring the data. The case-survey analysis, which is also referred to as the structured content analysis of cases (Jauch, Osborn, & Martin, 1980) or the meta-case analysis (Bullock & Tubbs, 1990), was chosen as a result of the following criteria (Larsson, 1993):

- The research area comprises a large number of case studies (i.e., cases of BPC projects) (Yin & Heald, 1975),
- The unit of analysis is the organization (i.e., the organization conducting the BPC project) (Jauch, Osborn, & Martin, 1980),
- A broad range of impact factors is of interest (Jauch, Osborn, & Martin, 1980),
- It is difficult to carry out structured primary research across cases in this research domain.

The qualitative SD method was chosen as it helps to obtain a basic understanding of the feedback concepts in BPC projects as well as to visualize the relationships with the help of CLD.

In the second quantitative phase, a quantitative SD simulation modeling was the dominant method. The quantitative SD simulation modeling method, which provides a basis for experimentation, predicts behavior, answers "what-if" questions and provides knowledge about the system being modeled (Kellner & Raffo, 1997). The literature proposes a distinction between two levels when choosing a simulation modeling method: the abstraction level and the time continuity level. (Borshchev & Filippov, 2004). The abstraction level further distinguishes between: (1) nano level, which is the most detailed view; (2) micro level, which has a more abstract view on an operational level; (3) macro level, which has the highest abstraction level therefore is also called strategic level, and (4) meso level, which includes only medium details. The choice of the level depends on the problem statement. Sometimes the model can include more than one level. The second dimension is the time dimension. The literature differentiates between two main kinds of simulation models in the time dimension: discrete models and continuous models (Borshchev & Filippov, 2004). In the discrete model, the state of variables changes only at the event times. Examples of time discrete simulation are Discrete Event (DE) and Agent Based (AB) simulation. AB models are mainly time steps defined, whereas DE models react to triggers and certain events. AB models can cover all kinds of abstraction levels. Continuous modeling, on the other hand, is useful when controlling systems with dynamic variables that change over time, such as productivity, quality and efficiency. Examples of continuous modeling are SD and Dynamic Systems (DS). The difference between these two types is on the dimension of the abstraction level. Figure 4 summarizes these simulation types according to their abstraction level and time continuity.

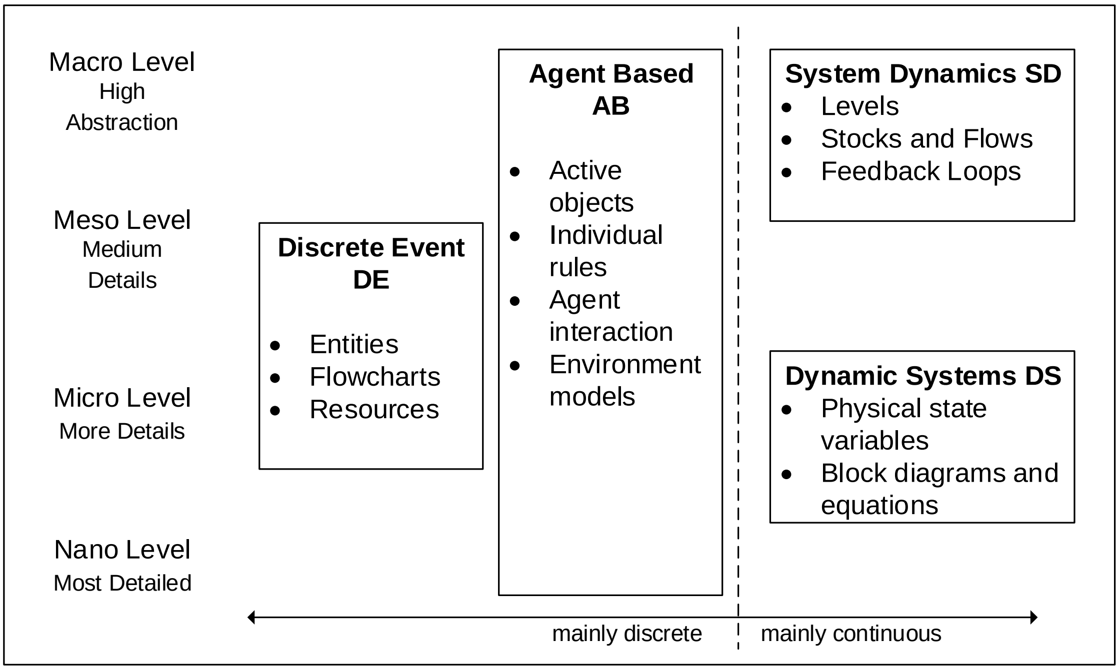

Figure 4. Classification of SD based on abstraction and time continuity level (Adopted from Borshchev & Filippov 2004)

Since discrete models are based on the idea of sequence activities, which are triggered at the event times, it is difficult to represent simultaneous activities. This can cause problems when integrating the continuous variables or may create instability in the behavior of feedback loops if a discrete model is used (Borshchev & Filippov, 2004). Furthermore, successful BPC initiatives are strategy-driven. I.e. BPC is always a strategic change (Grover & Kettinger, 1995; Grover, 1999; Guha et al., 1997). From this background, we adopted an SD modeling approach because of its rigorous method in capturing interrelationships among variables, handling dynamic aspects, simulating continuously changing variables and focusing on a macro-strategic level.

For the model validity we applied a policy sensitivity analysis. We ascertained that the policy sensitivity analysis was useful in our research as the purpose of this analysis is to test the sensitivity of policy recommendations. This is more useful than a simple sensitivity analysis that it is often used to judge the sensitivity of uncertain assumptions about model formulations and parameter values (Moxnes, 2005).

The following subsection gives a brief overview of the research methods used in this thesis. Firstly, we describe the case-survey method which was used to investigate impact factors and their causal relationships in BPC projects systematically. Secondly, we describe the SD methodology which we used as our modeling approach for the analysis of dynamic complexities in BPC projects. The detailed procedures are given in the respective papers. In this section, we focus on the characteristics of each research method.

3.1.1 Case Survey

The case-survey method was originally developed for public policy analyses (Lucas, 1974; Yin & Heald, 1975). The case-survey method is an inexpensive and powerful method that allows the transformation of qualitative data into quantitative results (Lucas, 1974) by applying a coding scheme and expert judgements by multiple raters (Larsson, 1993; Lucas, 1974; Yin & Heald, 1975). It centers on synthesizing fragmented contributions to maximize the amount of information that can be extracted from case studies (Larsson, 1993). The case-survey method is unique as it analyzes original qualitative case studies in a structured and quantitative manner (Newig & Fritsch, 2009).

The case-survey method has been successfully employed and further developed in a wide spectrum of research topics and disciplines ranging from political science (Lucas, 1974; Yin & Heald, 1975), management science (Larsson, 1993), public administration (Jensen & Rodgers, 2001), organizational development (Bullock, 1986) to the study of decision processes or impact factors (Lacity et al., 2011; Stahl & Kremershof, 2004). These studies have proven that case-survey is a powerful and rigorous approach.

Larsson (1993) proposed four main stages of the case-survey method which should be followed if rigorous outcomes are to be achieved: (1) select a group of existing case-studies relevant to the chosen research questions, (2) design a coding scheme for systematic conversion of the qualitative case description into quantified variables, (3) use multiple rates to code the cases and measure their interrater reliability and (4) statistically analyze the coded data.

Selection of a relevant case data set. The identification of the case study sample is one of the most crucial stages in the case-survey method (Jurisch, Wolf, & Krcmar, 2013). In order to achieve reliable and generalizable results some authors (Jurisch, Wolf, & Krcmar, 2013; Larsson, 1993) suggest three steps for systematical identification of the case studies: (1) developing research questions, (2) definition of case selection and rejection criteria and (3) collection of case studies. Carefully structured and clear defined research questions are the obvious starting point for a case-survey (Larsson, 1993). These research questions can either have an exploratory character of the contents or be used for theory-driven tests of hypotheses (Larsson, 1993).

The second step involves very clear selection and rejection criteria (Bullock & Tubbs 1990) in order to decide upon which cases should be included in the case-survey sample (Lucas, 1974). The identification of the right sample is essential for the generalizability of the case-survey results and should involve a systematic search of as many relevant case studies in an investigated area as possible (Lucas, 1974). Furthermore, these case studies should report a rich amount of data on the phenomenon of interest within each case study. Otherwise the case study would need to be discarded (Larsson, 1993). Further, case studies reporting the same empirical evidence should either be combined in one coding set or one of them should be dismissed (Bullock, 1986). Otherwise, the findings would be counted twice.

The last step, the collection of case studies requires a search strategy that should cover as many sources as possible in order to minimize any source-specific biases (Larsson, 1993). Larsson (1993) suggests that research publications, dissertations, conference papers, teaching cases, business literature, or unpublished sources should be included. However, to collect all relevant case studies is almost impossible (Larsson, 1993) therefore a researcher has to decide whether the total sample or a random subset of cases is used for the coding (Newig & Fritsch, 2009).

Coding scheme for conversion of qualitative into quantitative data. This stage represents the core of a case-survey and focuses on the conversion of qualitative information into quantified variables using a coding scheme (Bullock, 1986). These coding schemes might be more comprehensive compared to conventional questionnaires but on the other hand they could also be simple yes-no schemes (Bullock & Tubbs, 1990). For both coding schemes it is recommendable to extract as much information as possible (Larsson, 1993). To minimize potential biases the researcher should even code all factors presenting possible unwanted influences (e.g., author, publication, selection, coding and other biases) as variables (Jurisch, Wolf, & Krcmar, 2013). Newig and Fritsch (2009) argue that "*coding twice as many variables implies considerably less than twice the effort*".

Coding of case studies and interrater reliability. The coding of the case studies involves assigning at least two, preferably three raters to each case study (Larsson, 1993). The raters systematically assign the codes (numbers) to units based on the coding scheme (Srnka & Koeszegi, 2007). To achieve a high interrater reliability each rater should code at least one pilot case study to become familiar with the coding scheme and compare their results for calibration purposes (Larsson, 1993). Larsson (1993) further suggests to resolve the discrepancies by applying a consensus approach.

Statistical analysis. In our research papers, the analysis relies only on simple descriptive statistics which mainly allow for the presentation of frequency distributions. For instance, Lacity et al. (2011) conducted a frequency count of 87 studies to identify the relevant factors impacting business process outsourcing.

3.1.2 System Dynamics

SD was initially developed by Jay W. Forrester as a method of analyzing the behavior of complex systems for improving management policies and organizational structures. (Forrester, 1961). SD is founded in control theory and the modern theory of nonlinear dynamics (Sterman, 2000). SD models are causal mathematical models underlying the premise that the structure of a system gives rise to its observable and, thus predictable, behavior (Forrester, 1976, 1985). Forrester (1961) defined the system as a collection of elements that continuously interact with each other over time to create a unified whole. A system is separated from its environment by a boundary which denotes what is in the system and what is not. This understanding of the structure of a system emphasizes the importance of analyzing the system from a more holistic viewpoint. An holistic view refers to a belief that complex systems can only be understood when they are considered in their entirety which is a necessary condition for effective learning (Sterman, 2001). Dynamics refers to the fact that systems can change over time.

SD is an approach that deals with the complexity of systems and allows decision-makers to understand complex systems and the implication of system intervention better (Forrester, 1992). Whereas complexity refers to finding the best solution out of a vast number of possibilities and not to the number of components in a system or the number of combinations that must be considered in making a decision. (Sterman, 2000). Thus, dynamic complexity can arise even in simple systems with low combinatorial complexity (Sterman, 2000). Sterman (2000) argues that dynamic complexity has its origin in many areas such as time delays, stock and flows, attribution errors and false learning and feedback.

SD represents, therefore, a rigorous approach used to understand dynamic aspects of the system behavior (Sterman, 2000). SD is based on differential equations and the system state of a dynamic system is given by the following differential equation (1):

$$(1)\ \frac{dX}{dt} = f(t, X, B)$$

where $X \in M$ and M is the state space, dX the change of the system state X, dt the time unit and f an operator which describes the evolution. This means that at a specific point in time t, a system can be described by a system state X. Depending on a set of exogenous and endogenous parameters B that influences the current state, the system may reach another system state in the progress of time.

A key SD concept is strongly related to Systems Thinking which states that structure determines performance (Senge, 2006). Given this, the system's structure can be applied to effect different behaviors of the system (Madachy, 2008). Thus, the improvement of a process involves an understanding and a modification of its structure (Madachy, 2008). Another underlying concept of SD is the existence of feedback processes. Elements of an SD model can interact through feedback loops where a change in one variable affects other variables over time which in turn affect the original variable (Madachy, 2008). Feedback loops are critical to understanding the interrelationships.

Multiple feedback loops might produce systems behavior which is not seen in the simpler systems and non-linearity can produce unexpected behavior in a system (Forrester, 1976). This means that the major inputs of the system can be altered without substantially affecting the output behavior of the system. This kind of behavior is common in models of complex systems. Several authors (Senge, 2006; Sterman, 2000) therefore argue that as a result of this complexity; (i.e. multiple feedbacks or non-linearity) it is generally not possible to solve even small models analytically. Instead, SD clearly depicts which parameters in a system can affect the whole system and by altering them, decision-makers can change the system behavior.

SD modeling consists of qualitative (or conceptual) and quantitative (or numerical) analyses. Qualitative analysis includes the composition of studied phenomena structures and identifies system variables and cause-and-effect relationships (causal feedback loops). The causal feedback loops are represented by a CLD capturing the underlying feedback loop structure of the studied phenomena. CLDs can be transformed into a simulation model, also referred to as system flow diagram (SFD) and calibrated for quantitative analysis using computer simulation (Quaddus & Intrapairot, 2001).

3.1.2.1 Causal Loop Diagram

CLDs are of particular interest to this thesis as they are the first step of SD modeling. CLD links key variables together and indicates the causal relationships between them. CLD is a representation comprising variables connected by arrows denoting the cause-and-effect relationships among the variables (Madachy, 2008). Causal relationships support the clarification of the actual structure of the examined problem since a clearer picture of the problem's structure which then improves understanding of the observed phenomena. (Forrester & Senge, 1980). Causally related variables indicate how the dependent variable behaves when the independent variable changes (Sterman, 2000). In CLD this behavior is supported with the help of the links' polarity which can be positive or negative. Positive polarity appears when a causal link from one element *A* to another element *B* produces a change in the same direction. Negative polarity appears when causal link from *A* produces a change in *B* in the opposite direction.

In a mathematical representation a CLD is defined as a tuple (V; E; φ; D) where the pair (V, E) is a directed graph with V and $E \subseteq V \times V$ denoting the set of variables and the set of links between them respectively (see Feola, Gallati, & Binder, 2012). Hence, any link e = $v_{1,} v_2$ ∈ E is an ordered pair of two elements $v_{1,} v_2$ indicating that e starts at $v_{1,}$ and ends at v_2. The function $\varphi: E \rightarrow \{\pm\}$, called the polarity map, labels the arrows either with a "$+$" or a "$-$" sign. All links with the delay of a CLD are collected into the set $D \subseteq E$. A feedback loop is a directed circle of the CLD graph. Richardson and Pugh (1981) defined feedback "*as a closed sequence of causes and effects, that is, a closed path of action and information*". A linear chain of causes and effects, which does not close back on itself, is called an open loop.

In CLD two distinct kinds of feedback loops might appear: a balancing (negative) and/or a reinforcing (positive) loop. To understand the behavior of both feedback loops better, consider a well-known example of the recruitment of human resources in Figure 5. B1 represents a balancing feedback loop. Balancing feedback loops are self-correcting (Sterman, 2000). I.e. they attempt to reduce the discrepancy between the current and a desired state. We see from the diagram that total workforce influences workforce gap which in turn influences advertisement rate. Both an increase in the workforce gap, or the difference between the total workforce and the desired number of employees will produce an increase in the advertisement rate. Hiring new employees serves to increase the total workforce and reduce the workforce gap. R1 in the CLD represents a reinforcing feedback loop. The reinforcing feedback loops are self-reinforcing (Sterman, 2000). I.e. they reinforce the continuing trends in growth or decline. In this case, if total workforce rises the quit rate rises as well. The increase in quit rate produces an increase in the workforce gap and the cycle continues.

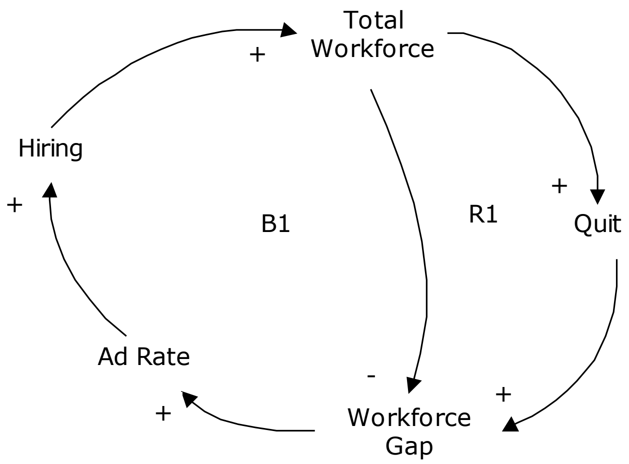

Figure 5. CLD of the recruitment of human resources
(Adapted from Sterman 2000)

CLD is a useful concept for understanding the interdependencies, feedback processes and delays and it helps to uncover the complexity of a system's nature. However, CLDs suffer from several limitations such as their inability to capture stocks and flows which are necessary concepts for simulating the dynamic behavior of the given system (Sterman, 2000). Thus, in many cases modelers convert their CLDs into SFDs in order to simulate the dynamic behavior of the given system.

3.1.2.2 Stock and Flow Diagram

SFD formulation elaborates the conceptual structure into detailed equations for simulation. Shannon (1998, p. 7) defines simulation as "*the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behavior of the system and/or evaluating various strategies for the operation of the system.*" The results of such simulations can help decision-makers forecast, solve problems and develop policies. (Baguma & Ssewanyana, 2008). Moreover, the decision-maker can model a variety of scenarios and observe how the system might behave under different conditions.

SFDs consists of stock and flow variables which are, along with feedback, the two central concepts of SD. Stocks (also called levels or state variables) are an accumulation, or an integration, of flows over time and characterize the state of the system as well as generate information needed for further decisions and actions (Sterman, 2000). Stocks can change their content only through inflow or outflow. In SD these flows, which increase and decrease the stocks, are called rates. These rates will always originate somewhere and terminate somewhere. However, there are situations where the origin or the destination of the flow is uninteresting. In such cases, the flow's origin is called a source and the flow's destination is called a sink. These both indicate that flows come from, or go to, somewhere outside of the model. Their presence signifies that real-world accumulations occur outside the boundary of the modeled system (Madachy, 2008). They are infinite supplies or repositories that are not specified in the model (Madachy, 2008). SD uses a particular notation for stocks, rates, sources and sinks (see Figure 6).

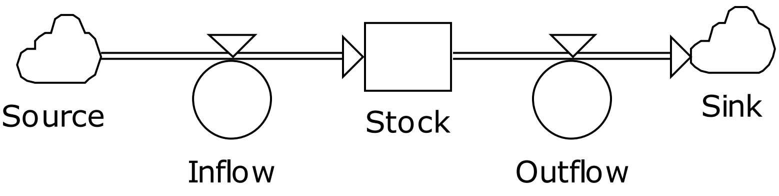

Figure 6. Representation of rates and stocks

The stock accumulation of its flows as in can be expressed further by the following integral equation (2) (Sterman, 2000):

$$(2)\ \mathrm{Stock(t)} = \int_{t_0}^{t} [\mathrm{Inflow(s)} - \mathrm{Outflow(s)}]\mathrm{ds} + \mathrm{Stock}(t_0)$$

where Inflow(s) represents the value of the inflow at any time s between the initial time t_0 and the current time t. Equivalently the net rate of change of any stock, its derivate, is the inflow less the outflow, defining the differential equation (3):

$$(3)\ \mathrm{d(Stock)/dt} = \mathrm{inflow\ (t)} + \mathrm{outflow\ (t)}.$$

In addition to the variable symbols shown in Figure 6, models might also include auxiliary or constant variables (see Figure 7).

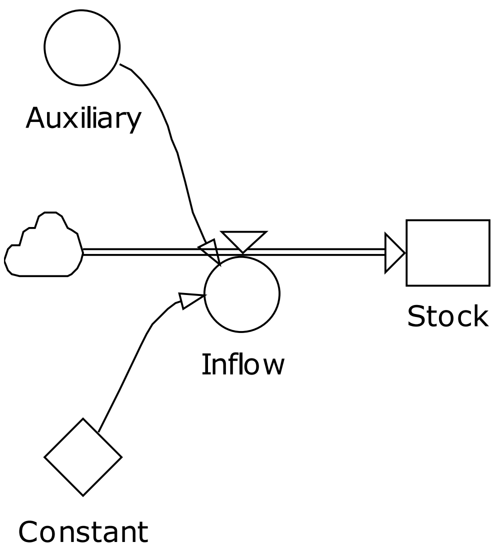

Figure 7. Representation of auxiliary and constant variables

Even though auxiliary and constant variables are not necessary for the description of a system, they both are fundamental to effective modeling (Sterman, 2000). They are used for the clarity and simplicity of the model since each equation in the model should represent only one main idea (Sterman, 2000), otherwise the resulting long conjoint equations will be difficult to understand and adapt. Auxiliary variables consist of functions of stocks whereas constant variables define parameters which are assumed to be unchanging throughout a particular simulation.

3.1.2.3 System Dynamics Modeling Procedure

Baguma and Ssewanyana (2008) proposed five main stages of the SD simulation method which should be followed if rigorous SD model is to be achieved. This process covers five major phases: (1) problem statement, (2) data-gathering and analysis, (3) conceptual model building, (4) SD model building and (5) scenario planning and model validity.

The first phase *problem statement* involves the formulation of the problem and the description of the objectives and goals. We formulated and defined the original problem at the beginning of this thesis. The overall objective is to explore the dynamic complexities in BPC initiatives by the development of an SD simulation model. In this vein, we want to visualize the effects of different decisions in BPC implementations.

The second phase *data gathering and analysis* starts with collecting and analyzing data for the SD simulation model. SD literature proposes several quantitative and qualitative methods for data collecting. Quantitative methods can be classified into four major types: (1) control theory, (2) pathway participation metrics, (3) eigenvalue elasticity analysis and (4) eigenvectors and dynamic decomposition weights. However, these approaches cope with the complexity of their application and therefore are not in widespread use in the SD community (Hayward & Boswell, 2014). On the other hand, qualitative methods such as interviews, oral history, focus groups, observations, participation observations and experimental approaches are the main sources of information in the modeling process (Forrester, 1994). In the next phase, these qualitative data need to be translated into analyzable data. Literature proposes several methods for qualitative data analysis such as founded theory, hermeneutics, discourse analysis and case-survey analysis.

The third phase *conceptual model building* concerns the qualitative or conceptual model building. This includes putting together the relationships between the relevant parameters. We visualize these relationships with the help of CLD, in order to get a basic understanding of the feedback concepts in BPC projects.

The fourth phase *SD model building* includes the transformation from qualitative to quantitative simulation model. This transformation process includes on the one hand the conversion of data into simulation elements, such as stocks and flows and on the other hand the quantification of these data. I.e. numerical values and mathematical formulations are assigned to the model elements. Before running the simulation, SD performs logical checks and tests whether the model variables and equations are defined correctly. These logical checks lead back to the equation refinement and help attain a stepwise improvement of the model.

The last phase *scenario planning and model validity* includes several simulation experiments. I.e. running the final simulation model in several scenarios to answer different kinds of questions. With the help of these scenarios, it is possible to observe and analyze the effects of different variations in model elements. The model validity was established using policy sensitivity analysis which determines the effect of variations in assumptions on the model output (Sterman, 2000). More specifically, a policy sensitivity analysis tests different policy options with the model and observes their effects on the behavior of the system.

PART B

1 Using Case Survey Methodology to Extract Variables and Causal Links: An Example from Studying Business Process Change[4]

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Table 3. Fact sheet publication P1

Abstract. Business process change (BPC) projects are complex initiatives with many interrelated factors that still cause unforeseen delays and even cancellations. While research on BPC provides useful insights into successes and failures of BPC projects, we argue that these insights remain rather fragmented. We present a mixed-method approach to create a coherent picture by extracting variables and causal links within BPC projects. We do so by adopting case survey methodology and causal loop diagrams. We show the usefulness of this approach by analyzing and consolidating insights of 130 BPC case studies. We make two main contributions: (1) we show the potential of system dynamics in BPC research by integrating the fragmented research on BPC to achieve more coherent picture and (2) we contribute to the literature on qualitative methods used in system dynamics, as we propose to use case survey methodology for developing causal loop diagrams.

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1.1 Introduction

Organizations are confronted with rapidly changing environment, such as high market pressure and fast technological development. To remain competitive and profitable at the same time, many organizations strive to change their business processes to improve their efficiency and effectiveness, service quality, or reduce costs. However, a number of business process change (BPC) practitioners and researchers agree that BPC projects present complex and challenging endeavors, which are shaped by a number of different organizational and economic factors, such as organizational performance, leadership and management practice, which interrelate together (Ashayeri, Keij, & Broeker, 1998; Hill & McCoy, 2011). Given this complexity, it is not surprising that between 60% and 80% of all BPC initiatives fail (Jurisch, Cuno, et al., 2012). Thus, various researchers have addressed the topic of BPC projects success. However, their research outcomes produced to some extent conflicting results and only few reliable generalizations (Jurisch, Ikas, et al., 2012). Furthermore, empirical BPC studies are mainly focusing on one or few specific causal relations, e.g. impact of IT or change management on BPC success (Grover et al., 1998; Huizing, Koster, & Bouman, 1997), which somewhat stand isolated in the overall context of BPC success. Thereby, these studies tend to overlook the emergent and complex interactions that are fundamental to any BPC initiatives (Karimi, Somers, & Bhattacherjee, 2007).

Causal loop diagrams (CLD) might be helpful in such complex initiatives, as they provide insights into feedback processes and lead to a better understanding of the dynamic behavior of studied phenomena (Flood & Jackson, 1991). Nonetheless, the application of system dynamics (SD) respectively CLDs has not been a major focus in BPC research over the last two decades. Only few SD models for BPC have been reported in the literature (Ashayeri, Keij, & Broeker, 1998; Baguma & Ssewanyana, 2008; Burgess, 1998; Kristekova et al., 2012; van Ackere, Larsen, & Morecroft, 1993). The first reason might be, as Flood & Jackson (1991) reported is the fact that SD may not be suitable for such complex systems to begin with. Therefore, they suggest starting with other systems thinking tools such as soft systems methodology, or the viable system methodology. The second reason might be that many CLDs are created in close cooperation with clients, with the purpose to elicit and capture the knowledge in their mental models. However, the difficulty arises when to handle phenomena such as BPC projects that involves several stakeholders and duration of such BPC projects last over several years (Harrington et al. 1998). These might have the consequence that the important people and information, which are needed for the developing of CLD, are not available in the organization anymore. The third reason might be that the majority of BPC research is based on a single case study in specific domain (Caron, Stoddard, & Jarvenpaa, 1994), which limits its generalizability.

Despite these challenges, BPC research field builds on a wealth knowledge derived from a large number of case studies (Jurisch, Wolf, & Krcmar, 2013). Each of them provides valuable insights of past failures and successes of BPC projects (Grover & Markus, 2008; Grover et al., 1998; Guha et al., 1997; Huizing, Koster, & Bouman, 1997; Kettinger & Grover, 1995; Trkman, 2010). However, these insights remain rather fragmented and a coherent picture is missing (Jurisch, Wolf, & Krcmar, 2013).

Given this background, the goal of our research is to integrate the fragmented research on BPC projects to achieve a coherent picture. To achieve our goal, we applied a mixed-method approach for extracting variables and relationships using a case survey methodology as a qualitative approach for developing causal loop diagrams. The recent study of Jurisch, Wolf and Krcmar (2013) shows the potential of applying case survey methodology in information systems (IS) research. They argue that case survey methodology is a powerful approach for identifying main factors of studied phenomena and getting deep insights into the importance of the identified factors. Furthermore, they argue that the generalizability power of such research results increases, as the results are based not only on one or few case studies. Larsson (1993) emphasize that the advantage of the case survey method is the application of a coding scheme of variables on the case studies and the possibility of many researchers using the coding scheme and comparing their results. This method is also helpful if the "unit of analysis is the organization" (Larsson, 1993) as it is often "used in the business policy area" (Jauch, Osborn, & Martin, 1980) and if there exists a great number of case studies (Jauch, Osborn, & Martin, 1980).

We make two main contributions: (1) we show the potential of SD in BPC research by integrating the fragmented research on BPC to achieve more coherent picture and (2) we contribute to the literature on qualitative methods used in system dynamics (SD), as we propose to use case survey methodology for developing causal loop diagrams.

The remainder of the paper is organized as follows. In chapter 1.2 we provide an overview of methods that might be used for developing CLD and give an overview of BPC. In section 1.3, we outline our research approach and demonstrate the use of the proposed method by presenting our results. In chapter 1.4 we discuss our results and limitations and conclude the paper in chapter 1.5.

1.2 Theoretical Background

1.2.1 Data Collection Techniques for CLD Building

System dynamics (SD) literature proposes several qualitative and quantitative methods for collecting data that support the process of modeling CLDs.

Quantitative data collection methods

Quantitative methods can be categorized into four major types: (1) traditional control theory, (2) pathway participation metrics (e.g., Mojtahedzadeh et al., 2004), (3) eigenvalue elasticity analysis (e.g., Kampmann, 1996), (4) and eigenvectors and dynamic decomposition weights (e.g., Guneralp, 2005). However, according to Hayward (2012) these approaches cope with the complexity of their application and therefore are not yet in widespread use in the SD community. From this background, we focus more on qualitative methods for data collecting that support the modeling process of CLDs.

Qualitative data collection methods

(Forrester, 1994a) identified qualitative data as a main source of information in the modeling process, which is residing in the mental models of the actors' heads. The basic qualitative methods used in SD are: interviews, oral history, focus groups, Delphi groups, observation, participation observation and experimental approaches that lead to qualitative data. These methods have been approached from a multitude of perspectives. It is beyond the scope of this paper to provide an in-depth account of literature concerning these methods. The focus lies only on a brief overview of these methods. For further reading on qualitative methods, we refer to (Bernard, 1999).

Interviews

A large portion of CLDs relies on interview data. Interviews are conducted either in person or over telephone, where the interviewer and interviewees draw on their interactional competencies. The main role of the interviewer is to guide the interview, clearing up any confusion, as well as remain neutral so that the respondent's remarks are not biased by the behavior of the researcher (cf. Luna-Reyes & Andersen, 2003).

Oral history

Oral history in contrast to interviews tries to elicit a particular data in the history that might not be represented in the written record. Oral histories are interviews of individuals in which researcher is looking for stories rich in detail and explanation (Luna-Reyes & Andersen, 2003).

Observation and participant observation

The modeler observes some aspects of reality, referred to as the "universe of discourse" and tries to distinguish a set of entities that compose the universe of discourse and the relationships between them (Richardson & Pugh, 1981). Conceptualizations are in effect, a lens through which the modeler observes phenomena of interest in a universe of discourse. However, observation and participant observation copes with several issues, such as permission for observation, whether the observer should announce his/her presence in the social situation, or how the awareness of observation could affect the results of the study.

Focus groups

Focus groups represents a method, where data collection is elicited from a group of respondents who interact with each other in the research environment (Luna-Reyes & Andersen, 2003). Focus groups are similar to group model building. The group is managed by a facilitator, who is responsible for the elucidation of knowledge within the group and thus, help the group to design one or more models (Rouwette et al. 2002). The research on focus groups has highlighted the value of directly involving many clients (groups) in the modeling process, as through them more shared perspective on the problem and on potential solutions is created (Richardson & Andersen 1995; Vennix et al. 1997). Andersen et al. (1997) and Vennix (1996) identified two main structural components necessary in focus groups: (1) the group structure, which takes the participants, the group and sub-group composition involved in each session and the facilitation aspects into account; (2) the logistic component, which includes all the aspects related to the location, fitting and equipment of the room.

Delphi groups

Delphi groups are an extension of focus groups (Luna-Reyes & Andersen, 2003), where the group might be geographically dispersed. The facilitator asks the clients and stakeholders to elaborate a list of issues on the given problem situation. There exist several approaches to collect the data from the geographically dispersed groups, such as asynchronously through list-servers and online discussion lists (Rohrbaugh, 2000). After collation, the groups send the material back to the facilitator individually or in a second Delphi group. The next task of the facilitator is to rank the results according to some standards.

A number of hybrid approaches that involve the client participation, have evolved over the years. For example: (1) Problem Structuring Method (PSM) (Mingers & Rosenhead, 2004), (2) the reference group approach (Stenberg, 1980). (3) the strategic forum (Richmond, 1997), (4) the stepwise approach (Wolstenholme, 1992), (5) modeling as learning (Lane, 1992), (6) the "standard method" of Hines (Otto & Struben, 2004); or (7) Holon Dynamics (Lane & Oliva, 1998).

1.2.2 Methods for Qualitative Data Analysis

Once, we obtain the text data gathered through interviews, observation, or focus groups, a question arises how to translate these relevant data into a causal loop model. We present two methods for qualitative data analysis, which were successfully used by SD researchers. Other methods such as hermeneutics or discourse analysis might be used as well, however, we did not identify any article in the literature that uses these method for developing CLD.

Grounded theory

Grounded theory is according to Strauss & Corbin (1998) a theory, which is derived from data, systematically gathered and analyzed through the research process. The texts used in grounded theory might come from transcripts of interviews, meeting minutes, or other kind of textual data. Yearworth and White (2013) in their current work presented a mixed-methodology that combines the qualitative data analysis process of coding with that of developing CLDs. They described the creation of CLDs from the coding threes, which were developed through a grounded theory approach and through using computer aided qualitative data analysis software. With their work, they try to highlight the need within SD community to ground models in a formal qualitative data analysis to enhance its formality and rigor.

Content analysis

Content analysis is a powerful approach for identifying main factors of studied phenomena and getting deep insights into the importance of the identified factors of (Jurisch, Wolf, & Krcmar, 2013). The researcher starts by defining the set of codes, which are systematically applied to a set of texts from written documents, or transcripts of interviews or focus groups. The coding results are mainly organized into a matrix of codes. Critical issue in content analysis is the reliability of the coding process, as the results are based on subjective judgments of the coder. Therefore, an inter-coder reliability (such as Krippendorfer's alpha) should be established at the outset of the coding process. Deegan (2011) in his work presented a multi-methodology for analyzing policy complexity and intergovernmental relationships using content analysis and causal maps, as a way to analyze arguments identified in two unique reports. In these reports, he coded relationships, which resulted in 97 causal loop diagrams. He further used causal maps to deconstruct arguments into individual components (i.e. causal links) and used these components to identify the size and scope of a recommendation.

1.2.3 Business Process Change

BPC is an elusive term that is frequently confounded with a number of terms with similar, though not necessarily identical, meanings (e.g., business process reengineering (BPR) or business process transformation (BPT)) (Sarker, Sarker, & Sidorova, 2006). The term BPC was coined by Grover and colleagues (Grover, Kettinger, & Teng, 2000; Grover & Kettinger, 1997, 2000; Kettinger, Teng, & Guha, 1997) in an attempt to shift the focus on the importance of process instead of the radicalness of the change. In the 1990s, radical change (such as BPR) was the dominant tenor. However, the focus of reengineering processes on the account of people and performing major work force reductions frequently did not yield the anticipated results (Grover, Kettinger, & Teng, 2000). Today, BPC reflects a management concept that involves any type of process change (radical and continuous). As such the term BPC "is more inclusive and avoids the negative connotations of some of the earlier-used terms such as BPR" (Sarker, Sarker, & Sidorova, 2006). In the following, we define and differentiate the major terms connected to the realms of BPC (see Table 4 for a summary).

Name	Definition	Scope of change	Sources
BPM	Corporate management philosophy and discipline		(Brocke & Rosemann, 2009; Van Der Aalst et al., 2003)
BPC	Management concept that involves any type of process change	Radical & continuous	(Grover, Kettinger, & Teng, 2000; Niehaves, Plattfaut, & Sarker, 2011; Sarker, Sarker, & Sidorova, 2006)
TQM	Management concept	Continuous	(Tan & Yap, 1994; Zink, 2004)
BPR/BPT/BPI	Method	Radical	(Davenport, 1993; Grover & Markus, 2008; Hammer & Champy, 1993)
Six Sigma	Method (statistical)	Continuous	(Nave, 2002; Revere, Black, & Huq, 2004; Sidorova & Isik, 2010)
Kaizen/CPI	Method	Continuous	(Brunner, 2008; Suárez-Barraza & Lingham, 2008)

Table 4. Overview of terms in the context of BPC

The idea of viewing work-related activities as processes and improving them is not new. In fact, these concepts date back to the beginning of the twentieth century and probably even before (Grover & Markus, 2008). The emergence of the term “BPM” is hard to pin down in terms of time and space. Nonetheless, BPM, like BPC, has its origin in the works of Frederick Taylor.

Modern BPM is not a monolithic principle, but rather a wide umbrella of activities, concepts, approaches, methods, techniques and tools for designing, controlling, analyzing and changing processes in organizations (Mathiesen, Bandara, & Delavari, 2011). Van Der Aalst et al. (2003), define BPM as “supporting business processes using methods, techniques and software to design, enact, control and analyze operational processes involving humans, organizations, applications, documents and other sources of information.” Based on this definition, BPM is best understood as a process-oriented management discipline (Hill, Massimo, & Yefim, 2008).

BPC refers to a management concept that involves any type of process change – revolutionary/radical or evolutionary/continuous (Grover, Kettinger, & Teng, 2000; Grover & Markus, 2008) as well as quality programs, enterprise resource planning (ERP) implementation or the retooling of business processes for e-commerce (Sarker, Sarker, & Sidorova, 2006). While both approaches, radical (e.g., BPR, BPT, BPI) and continuous (e.g., TQM, CPI, six sigma), share the common goal of improving processes, they are also frequently used complementary (Grover & Markus, 2008). Margherita and Petti (2010) posit that many projects are only labeled as BPR while they are in fact “normal improvement activities which are unlikely to bring radical innovation within the organization”.

Total Quality Management (TQM) is an integrative management concept (Zink, 2004). TQM is considered to be a more evolutionary and continuous concept to constantly optimize and change business processes (Bucher & Winter, 2007). Furthermore, it aims at improving the quality of products and services in all departments and functions (Koch, 2011). TQM consists of different concepts for continuous process change (e.g., Kaizen, Six Sigma).

Hammer & Champy (1993) define BPR as the fundamental rethinking and radical redesign of business processes. Research shows that the implementation of BPR often results in fundamental changes of the organization’s structure, culture and processes (Al-Mashari & Zairi, 2000; Cao, Clarke, & Lehaney, 2001). The successful implementation of BPR can result in dramatic improvements in critical efficiency and effectiveness measures such as cost, quality, service and time (Jurisch, Ikas, et al., 2012; Sharafi et al., 2011). Past experiences also show that all BPR implementations are effectively change management programs (Cao, Clarke, & Lehaney, 2001; Sinclair & Zairi, 1995). Hence, BPR not only necessitates top management support, but also bottom-up employee empowerment (Paper et al., 2001).

BPR, business process innovation (BPI) or business process transformation (BPT) are frequently used synonymously for the same phenomenon. According to Grover and Markus (2008) these variations in name of essentially the same concept were part of a bandwagon effect. All BPR, BPI and BPT projects are radical, revolutionary and one-time undertakings (Davenport, 1993; Grover, Kettinger, & Teng, 2000; Grover & Markus, 2008; Hammer, 1990).

Kaizen originated in Japan and is a continuous process improvement method. In the West, Kaizen can be translated into Kai = Change + Zen = Good (Autorenteam, 1994). It refers to many minor changes in an organization that are applied to existing products and services. More so, Kaizen is a bottom-up approach, which is frequently pursued by employees at lower levels within the organization. Suárez-Barraza & Lingham (2008) summarize Kaizen as a method that involves all the employees of the firm, implements small and incremental improvements and uses teams as the vehicle for achieving incremental changes.

Six Sigma has been promoted as a more continuous organizational change and improvement method (Sidorova & Isik, 2010). Six sigma projects rely on statistical methods to identify problems. Six sigma projects include the designing, improving and monitoring of business processes with the goal of reducing costs and enhancing throughput times (Nave, 2002; Revere, Black, & Huq, 2004).

1.3 Extracting BPC Variables and Causal Links

1.3.1 Case Survey Methodology

To extract variables and causal links, we applied case survey methodology, also referred to as structured content analysis of cases (Jauch, Osborn, & Martin, 1980) or case survey (Larsson, 1993; Lucas, 1974; Yin & Heald, 1975). The case survey methodology turned out to be particularly useful for our research due to the following criteria proposed by (Larsson, 1993): (1) the research area comprises a huge number of case studies (i.e., cases of BPC projects) (Yin & Heald, 1975); (2) the unit of analysis is the organization (i.e., the organization conducting the BPC project) (Jauch, Osborn, & Martin, 1980); (3) a broad range of impact factors is of interest (Jauch, Osborn, & Martin, 1980); and (4) it is difficult to do structured primary research across cases in this research domain.

1.3.2 Sample Collection

We performed a detailed screening of literature. We start our search in traditional channels (e.g., libraries), conference proceedings, online database services (e.g., Emerald, EBSCO, Science Direct and Google Scholar), consulting journals and other web search tools. We searched for following key words: “business process”, “business process change”, “business process reengineering” and “business process transformation”, each with the combination the term “case study”. The selected key words resulted in more than 5,000 references. In the next step, we explored titles, abstracts and keywords and reduced the sample to 217 case studies. In our last step, we excluded case studies that (1) have none or very little information about the case; (2) none or very little information about the impact factors; and (3) focused on the technology and not on the BPC initiative. Our final sample consisted of 130 case studies, consisting of 86 journal articles, 22 book sections, 16 conference articles, 4 theses, 1 working paper and 1 magazine article. The final sample spans the years 1993 to 2012 and have an average length of 14 pages.

1.3.3 Identification of Variables

The coding scheme "documents and guides the conversion of qualitative case study data into quantified variables" (Larsson, 1993) and thus stands as the core element of a case survey methodology. In line with Larsson (1993), our coding scheme comprises variables that represent the aspects of the study design (e.g., employee expertise, IT infrastructure employment, or BPC tools and techniques) and the publication status (e.g., ranging from journal article to book section). As a result, a master list of the variables evolved, which we employed for the frequency coding; i.e. for aggregating the findings across the studies.

1.3.4 Data Coding

For the frequency coding of the variables and their relationships, we applied a methodology proposed by Lacity et al. (2010). Following this methodology, we analyzed how often variables from our master list occurred in a case study. We counted the frequency of the words and their synonyms, as some words may have multiple meanings, we always counted the word-frequency in the whole sentence context. Afterwards, we empirically examined the relationships between the variables. To determine the direction of any causality, we set column variables as our starting variables and use a simple one-way causality notation. We assigned two possible values: '+1', '-1'. We coded '+1' for positive relationships, '-1' for negative relationships. We treat all coded variables and relationships as significant, as also variables and relationships that are coded only one time, might have a significant impact on the overall BPC project success.

To ensure consistent coding at the outset, we established inter-coder reliability. For each case study, two authors independently filled the coding sheets of our master list. Afterwards, we meet in person to compare codes and discussed the difference until we reached a consensus. At the outset, the results indicate a Krippendorf's Alpha of 0.68, which is an acceptable inter-coder reliability (Krippendorf, 1980).

1.3.5 Data Analysis

Based on our master list, which consists of 64 variables, we achieved a total frequency coding number of 2.079 in our set of case studies. Generally, the variables of the master list are divided into 11 broader categories, such as BPC project scope and outcome, change management, human and other resources, or project management. Table 5 summarizes the results of our frequency coding for these variables, which are sorted by frequency of use. Each broad category is briefly discussed below.

BPC variables	Freq.	BPC variables	Freq.
BPC Project Scope and Outcome		**BPM Capabilities**	
1. Process Efficiency	70	1. Business Process Measurement	60
2. Cycle Time	60	2. BPM Methods and Tools	37
3. Reduction of Costs	57	3. Past Change Projects	13
4. Process Effectiveness	53	∑	**110**

5. Customer Satisfaction	42
6. Employee Satisfaction and Morale	41
7. Integration	40
8. Productivity	37
9. Quality of Products/Services	32
10. Complexity	22
11. Price/Performance Ratio	4
∑	**458**
Top Management Support	
1. Top Management Vision/ Understanding	66
2. Top Management Resource Support	36
3. Senior Management Commitment	34
∑	**136**
Project Management	
1. Governance Structure	70
2. Process Improvement Goals	49
3. Structure	40
4. PM Methods and Tools	38
5. Project Manager Practices	33
6. Managing Scope/Goal	30
7. Managing Stakeholder Interests	29
8. Managing Project Risk	25
9. Goal Appropriateness	23
10. HM/Resource forecasting	14
∑	**351**
Change Management	
1. Training	75
2. Communication	69
3. Change Understanding	49
Human Resources	
1. Consulting Support	69
2. Employee Expertise/Capabilities	38
3. Business Process Know-How	21
4. Project Manager Expertise	20
∑	**148**
IT Resources and Capabilities	
1. IT	50
2. IT Infrastructure Employment	38
3. IT Accessibility	37
4. IT Flexibility	21
5. IT Infrastructure Configuration	14
6. IT Know-How	13
7. IT Reliability	5
∑	**178**
Other Resources	
1. Adequate Budget Size	10
2. Other Resources	8
∑	**18**
Volatility in …	
1. Competitive Environment	20
2. Scope	17
3. Regulatory/ Governmental	13
4. Schedule	9
5. Business Strategy	8
6. Executive Sponsor	7
7. Budget	5
8. Supplier/ Vendor	3
9. Project Manager	1

4. Change Management Methods	45	∑	**83**
5. Formal Process	43	**Learning Capacity**	
6. Information Policy	41	1. Individual Learning	41
7. Capacity for Change	23	2. Organizational Learning	27
8. Perceived Capacity to Change	14	∑	**68**
9. Information Quality	14	**Process Management**	
10. Information Amount	12	1. As-Is Analysis	62
∑	**385**	∑	**62**
		Interdepartmental Integration	
		1. Cooperation	57
		2. Exchange of Ideas	25
		∑	**82**
		Grand Total ∑ ∑	**2.079**

Table 5. Coding results on variables used in BPC projects

BPC project scope and outcome

BPC researchers have studied a number of BPC outcomes. One of the most frequently studied variable is Process efficiency, examined 70 times. The improvements in process efficiency were especially achieved by reduction of Cycle times, which were in turn achieved by reducing non-productive time (R. Kennedy & Sidwell, 2001) and by the identification and elimination of delays (Buchanan, 1997). Reducing cost was the third most frequently used variable, as shown in the example of Xerox Group, which stated that their BPC project was only done because of the proposed cost savings (Harvey, 1994). Another case, the Chase Manhattan Bank reported a reduction of $790 million in their expenses after BPC project (Shin & Jemella, 2002). Another most frequently used variable captures Process effectiveness, which was coded 53 times and is closely connected to customer orientation (Martin & Cheung, 2002). According to Harrington (1991), the effectiveness of a business process is defined as the extent to which the output of a process meets the needs and requirements of its customers. Thus, the fifth most frequently studied variable in this broad category was Customer satisfaction, which was studied 42 times. For example, the Contributions Agency introduced the goal "Ensuring People are Valued", which helped staff to esteem themselves and their customers (Harrington et al. 1998). The Co-operative Bank established monthly reports with the intent that staff "can concentrate on improving what is important to the customers and not on what they think is important" (Dignan, 1995). Researchers also studied Employee morale and considered it as a pivotal variable determining the success of BPC projects (Grover, 1999; McAdam & Donaghy, 1999). Other change projects tried to improve employee morale by "changing responsibilities from routine transaction processing to value-added accountability" (Ballou, 1995). Another important variable is Integration, which was studied 40 times. For example, an Indian refinery "estimated that the implementation of the integrated materials management system (…) helped them to reduce the inventory carrying costs by more than 30 percent" (Dey, 2001). The next variable "productivity" was examined 37 times. Pilkington Optronics stated "In ten years' time, the best would have a productivity gain of 10:1 and we want to be one of those" (Harvey, 1994). The effects of Quality of products and services, like the improvement of service levels (Currie & Willcocks, 1996; El Sawy & Bowles, 1997), were examined 32 times. For example, a major bank invested £100 million in its IT, which helped to achieve higher service quality (Newman, Cowling, & Leigh, 1998). The last variable in this broad category is the outcome Reduction of complexity, which was studied 22 times. For example, during the reengineering at ITT Sheraton the workforce was dramatically reduced, which lead to reduced complexity (Chand et al. 1997).

Top management support

BPC researchers have long understood the importance of Top management support for the success of the change project (Jurisch, Cuno, et al., 2012). The first most frequently examined variable in this category is Top management vision/understanding (examined 66 times), which considers the degree to which the project objectives pursued by the top management were clear (Harvey, 1994). The other most frequently studied variables in this broad category were Top management resource support (examined 36 times) and Top management commitment (examined 34 times).

Project management

Project management includes 11 variables, which examine a rich array of factors. One of the most frequently studied one was Governance structure (examined 70 times), which implies that a formalized governance structure was used for the project that is opposed to the existing one of the organization (Huizing, Koster, & Bouman, 1997). Process improvement goals (examined 49 times) are need to gain clear understanding of the direction the project is moving to (MacIntosh, 2003). The third most frequently studied variable was Team structure (40 times). For example, Capital Holding structured their BPC project according to a customer information system and pulled several cross-functional teams together (Hammer & Champy, 1993).

Change management

Change management represents category, whose variables were one of the most frequently studied ones by BPC researchers (385 times). One of the most frequently examined variable was Training (examined 75 times), which considers the education of the employees, affected by the change, to develop new skills for their new position, new role, or both (Gadd & Oakland, 1995; Harvey, 1994). Communication (examined 69 times) was the second most frequently studied variable in this category (Grover, 1999; Lee & Chuah, 2001). The third most frequently studied variable was Change understanding (49 times), which considers the degree to which employees understood the need for change (Francis & Alley, 1996), followed by Change management methods and tools (examined 45 times), formal process (examined 43 times) and information policy (Guha et al., 1997; Huizing, Koster, & Bouman, 1997).

Process management

This broad category examines three variables: (1) as-is-analysis (examined 62 times), which reflects the current state of the organization (Kettinger & Grover, 1995); (2) process management methods and tools (examined 52 times), which ranges from process maps (Shin & Jemella, 2002) to quality management tools (Francis & Alley, 1996); and (3) as-should-be-analysis, which was examined 25 times.

Interdepartmental integration

One of the most studied variable in this broad category was Cooperation (examined 57 times), which considers the degree to which members of different business units collaborate together throughout the change project (Guha et al., 1997). Followed by Formal integration (examined 29 times) and Exchange of ideas (examined 25 times).

Learning capacity

This category has been studied 68 times with two variables. Individual learning (examined 41 times) is characterized by individual experiences during change project (Martin & Cheung, 2002) and Organizational learning (examined 27 times). Collyer (2000) stated Learning is seen as essential key factor to successful project completion.

BPC capability

BPC capability, studied a total of 110 times, include three variables that consider Business process measurement (examined 60 times) to monitor the success of the business processes (Mathiesen, Bandara, & Delavari, 2011), BPC methods and tools (examined 21 times), an organization applied by the change project and past change projects (examined 13 times), which considers the degree to which an organization already successfully completed one or several change project(s).

Human and other resources

This broad category studied four variables. One of the most studied variable is Consulting support (examined 69 times), mainly used for an external objective viewpoint (Larsen & Myers, 1997) and methodology (Jackson, 1995). Followed by Employee expertise (38 times), Business process know-how (examined 21 times) and Project manager expertise (examined 20 times). Other resources comprise financial, organizational and physical resources (examined 18 times) (Melville, Kraemer, & Gurbaxani, 2004).

IT resources and capabilities

This broad category IT resources and capabilities refer to the necessary hardware, software and other technologies and tools, which were in place and played a significant role in the change project (Grover et al., 1998) and refer to the practices of an organization employed to mobilize and deploy IT-based resources (Bharadwaj, 2000; G. Kim et al., 2011). BPC researchers agreed among themselves that IT resources and capabilities are critical factors of process change (Davenport & Short, 1990; Grover et al., 1998; Venkatraman, 1994). IT capabilities refer to IT infrastructure employment (examined 38 times), IT know-how (examined 13 times), IT (re)configuration (examined 10 times) and flexible IT infrastructure (examined 4 times) whereas IT resources refer to IT (examined 50 times) or tools and methods (examined 21 times).

Volatility

This broad category examines variables concerning the Volatility throughout BPC projects, for example Competitive environment volatility (examined 20 times), Scope volatility (examined 17 times), Government volatility (examined 13 times), or Schedule volatility (examined13 times).

1.3.6 Analysis of Causal Links between BPC Variables

In this section, we summarize some of the major findings about the 852 relationships, we coded between the BPC variables. The elaborated relationships are presented with the help of CLD, which captures the interactions and relationships between the identified variables. Causally related variables indicate how the dependent variable behaves when the independent variable changes (Sterman, 2000). In CLD this behavior is represented with the help of positive or negative signs. We treat all coded relationship-frequency as significant, as also relationships coded only once may have a significant impact on the overall BPC project success.

Relationships between BPC scope and outcome variables

To keep the readability of the CLD, we partitioned it into five parts. Figure 8 summarizes the relationships between variables from the broad category BPC scope and outcome. The CLD model has 11 variables and nine variables (marked grey in "< >") from other CLD parts.

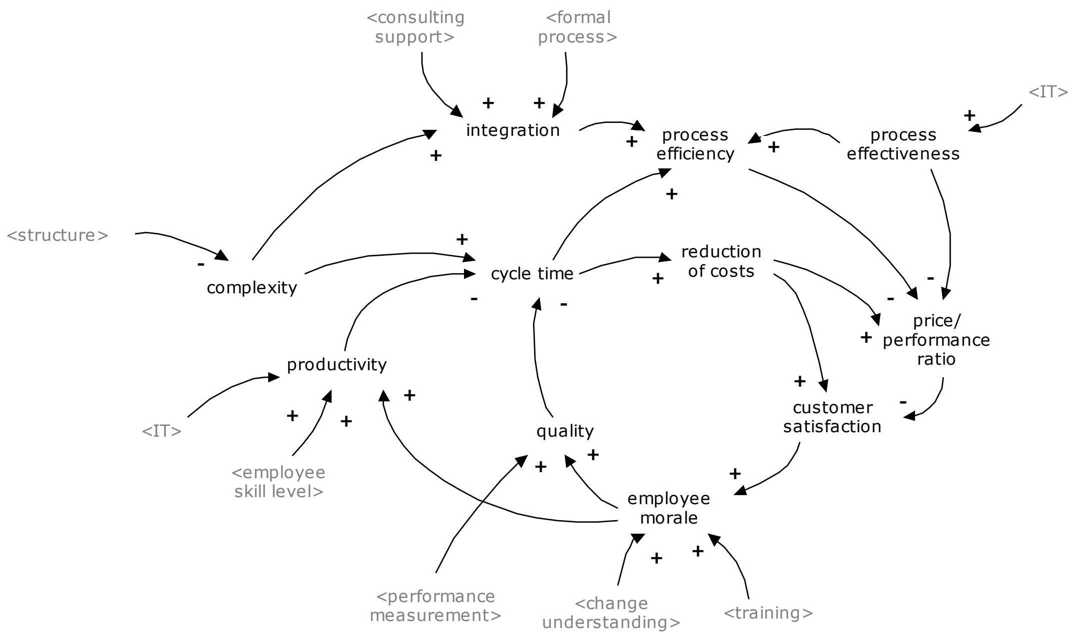

Figure 8. Causal loop model between BPC variables (part 1)

Starting with quality, which is positively influenced by employee morale, as highly motivated employee generate fewer errors. Expecting higher quality and high employee morale, in turn decrease the amount of cycle times (Proctor & Gray, 2006). Researchers found that the introduction of business performance measurement has underpinned the improvements in quality (Geier, 1997; Newman, Cowling, & Leigh, 1998). Productivity along with quality and reduced cycle times positively influences the overall process efficiency (Albizu, Olazaran, & Simon, 2004; Hesson, 2007; Thong, Yap, & Seah, 2000). Furthermore, IT represents another most significant factor that positively influences process effectiveness and productivity and thus has an indirect positive impact on reduction of cycle times and process efficiency (Geier, 1997; Harvey, 1994; Newman, Cowling, & Leigh, 1998). Other researchers (Davenport, 1993; H. J. Harrington, 1991) reported that process efficiency is positively influenced by integration and process effectiveness. Organizations strive to improve price/performance ratio to achieve the maximum of output with a minimum of input (Thommen & Achleitner, 2006), which is measured by efficiency and effectiveness (Jurisch, Cuno, et al., 2012). Low efficiency/effectiveness indicates high price/performance ratio and vice versa. Hesson (2007) found in his study that the result of increased process efficiency is an increase in satisfied customers. Moreover, the reduction of cost as well as low price/performance ratio play an important role by influencing customer satisfaction and employee morale (Weise, 1996); i.e. if employees drive the costs down, e.g., through reduction of cycle times, then employee morale and customer satisfaction increase. Newman, Cowling and Leigh (1998) observed that training positively influences employee morale and thus have an indirect effect on the overall quality. Furthermore, Wilckens & Pasquale (1995) reported that reduced complexity positively influence integration. In turn, formal process and consulting support are both enabler of integration (Harvey, 1994).

Relationships between BPC variables (part 2)

Figure 9 summarizes the relationships between variables from the broad category change management, top management support and volatility. However, for top management support and volatility, we used the broad category, as according to Forrester (1976) phenomena with similar structures may be aggregated together. The interfaces; i.e. variables from other CLD parts, are marked grey in “< >”.

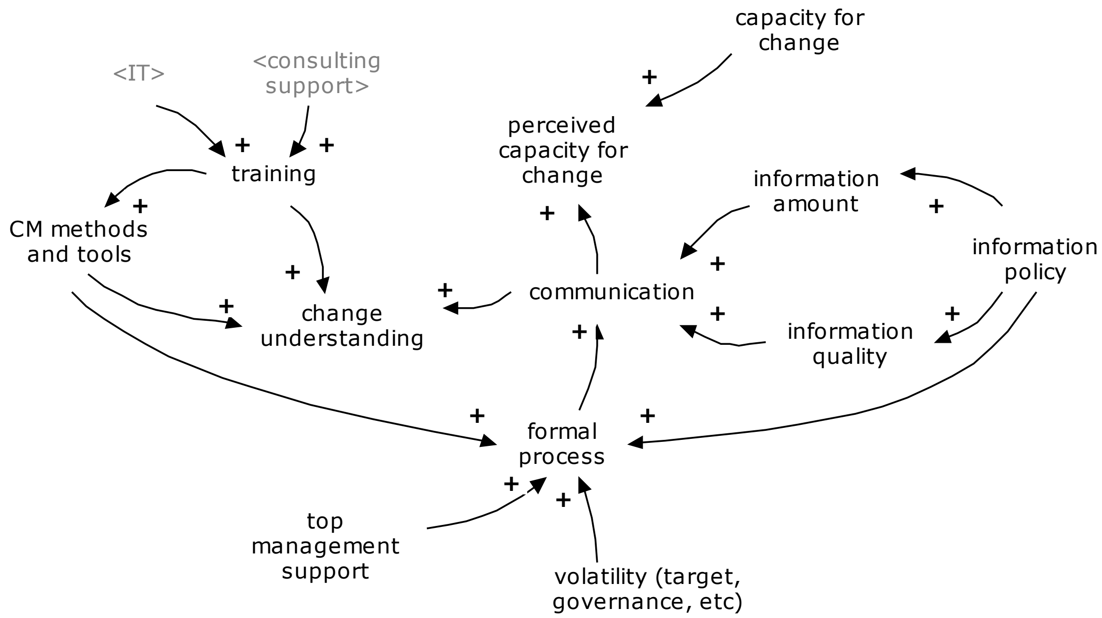

Figure 9. Causal loop model between BPC variables (part 2)

As seen in Figure 9 training positively influences change understanding. This relationship was observed by several researchers (Huq & Martin, 2006; Kennedy & Sidwell, 2001; Thong, Yap, & Seah, 2000). They all found that employees should be retrained to get an adequate knowledge they need for their new jobs in order to understand the new facets of the change project itself. Thus, several organizations offered training programs to those who needed it for their new roles. Consulting support played a significant role in training, as they provide the skills, methodology and transferred the knowledge to the employees (Martin & Cheung, 2002; Paper, 1997). As found by Geier (1997) IT has a supporting function in training and can be used for the support of all the process management functions. Training positively influences the use of change management (CM) methods and tools (Huizing, Koster, & Bouman, 1997). Hammer and Champy (1993) reported that communication is an important factor in reengineering projects due to their complexity and all the employees have to understand the change before reengineering can work. Additionally, an open information policy was established and necessary information where provided and communicated to the employees to understand the purpose of the reengineering project. Another example of how communication influences change understanding was observed by Huq and Martin (2006), where Midwestern hospital first reduced the resistance to change with an effective communication. To establish an effective communication they introduced an information policy in form of an ERP solution, which provided information for the employees via a single point of access to the corporate’s intranet. However, information policy influences information quality and amount, as it provides a way how the changes will be communicated to the rest of the company (Harvey, 1994). We also identify that communication and capacity for change both influence perceived capacity for change (Congram et al. 1999), so it is of great importance to change the ratio of capacity for change early on. Another factor, that has an effect on communication, is formal process, which considers at least the formal definition of the activities, scopes and roles and should be communicated to the affected stuff in order to be accepted (Guha et al., 1997). Another factors influencing formal process are top management support and volatility.

Relationships between BPC variables (part 3)

Figure 10 summarizes the identified relationships between the variables from the broad categories Human and other resources, learning capacity and interdepartmental integration. It consists of ten variables and four variables from other CLD parts, which are marked grey in “< >”.

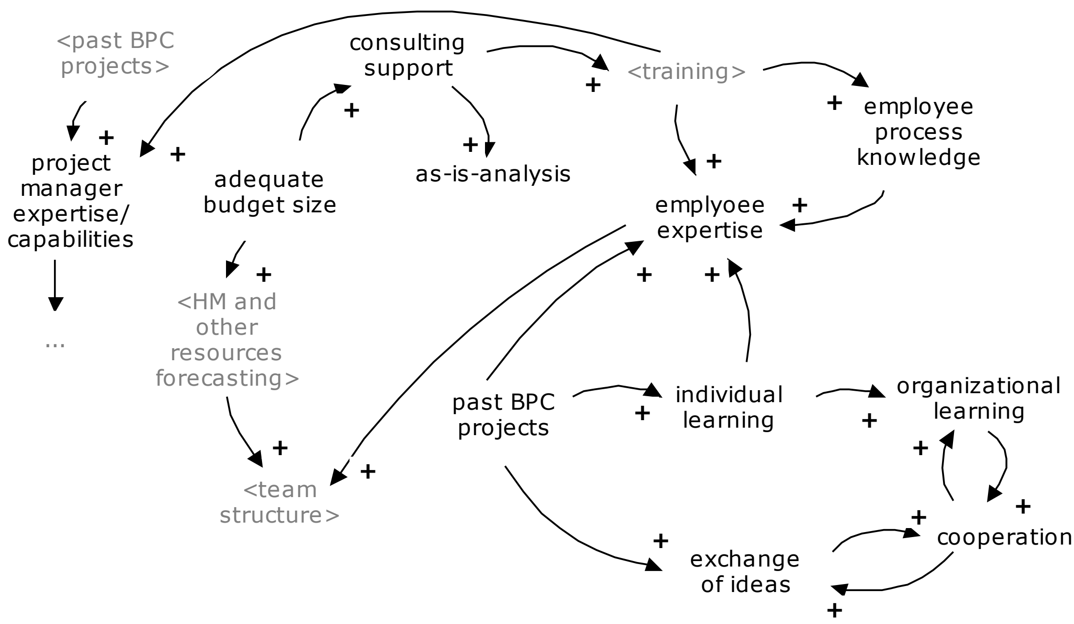

Figure 10. Causal loop model between BPC variables (part 3)

The current people capabilities, including project manager expertise and employee expertise are both influenced by past BPC projects and might be enhanced by training (Albizu, Olazaran, & Simon, 2004; Harvey, 1994; Huq & Martin, 2006; Lee & Chuah, 2001). Consulting support as discussed earlier plays an important role in transferring the knowledge to the people that are affected by the change project. Albizu et al. (2004) further observed that one of the first steps done in BPC project an organization done, was to hire consulting firms for an analysis of the current situation. Consulting support is directly affected by adequate budget size, as found by Albizu et al. (2004). Training enhances the employee process knowledge, which in turn enhances employee skills and capabilities. Employee expertise is further influenced by individual learning, which is characterized by individual experiences from past and current change projects (Martin & Cheung, 2002). Individual learning positively influences organizational learning, which can be further created through shared experiences (Martin & Cheung, 2002).

Relationships between BPC variables (part 4)

Figure 11 summarizes the identified relationships between the variables from the broad categories Project management and BPM capabilities. It consists of twelve variables and six variables from other CLD parts, which are marked grey in “< >”.

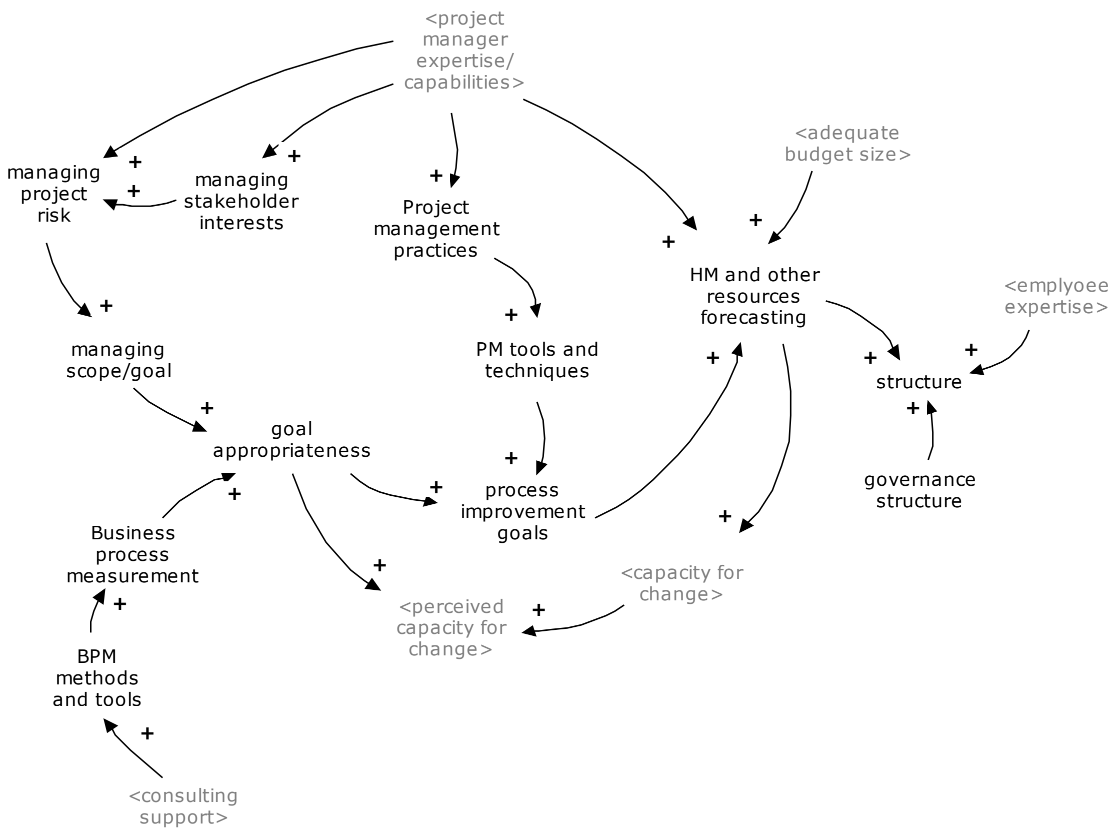

Figure 11. Causal loop model between BPC variables (part 4)

Both, managing project risk and stakeholder interest are positively influenced by the project manager’s capabilities. The project manager should establish a consistent and disciplined process for managing BPC projects risks; otherwise the consequences might be harmful to the organization. However, the impact of unfortunate events or the realization of potential threats into opportunities, elaborated from assessing risks, is mainly dependent by project manager capabilities (Congram et al. 1999). Managing stakeholder interest influences project risk, as their interests and concerns might affect the evolution of the whole project. Thus, meeting the expectations of stakeholders reduces the risk and mitigates the potentially negative influence on the overall change project (Newman, Cowling, & Leigh, 1998). Rigorous and proactive management of risks and stakeholder interests enable to manage project scope without problems (Al-Mashari & Irani, 2000). To ensure, whether the goal is still appropriate, measurement criteria should be established and used. Goal appropriateness positively influences the process improvement goals, which are more detailed than the general intended improvements (Grover, 1999). These improvement goals are influenced by project management tools and methods used in the project. According to Huq & Martin (2006), the use of methods and tools is dependent on project manager practices. Since each process improvement goal has its unique characteristics a structure must be designed carefully (Huizing, Koster, & Bouman, 1997). One of the main objectives of the structure is to define relationships among members of the project and the relationships with external environment. Thus, it is of great importance to consider the right resources, which will operate in the given change project. Structure can be further supported with new governance structure, which defines new roles and responsibilities of the employees (Hammer & Champy, 1993; Harvey, 1994).

Relationships between BPC variables (part 5)

Figure 12 summarizes the identified relationships between the variables from the broad categories IT resources and capabilities. It consists of seven variables and four variables from other CLD parts, which are marked grey in “< >”.

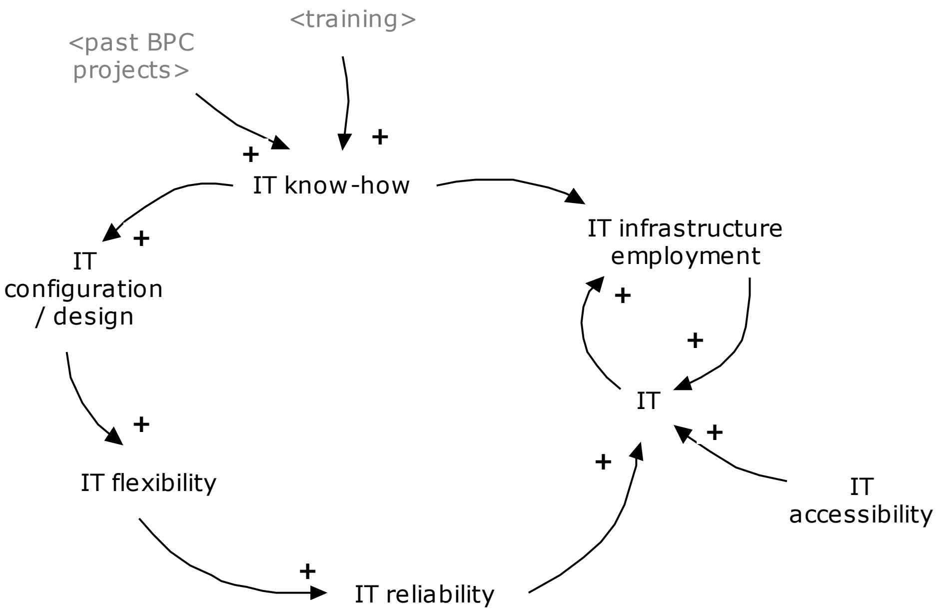

Figure 12. Causal loop model between BPC variables (part 5)

A number of researchers agree that the role of IT is a crucial factor in reengineering projects (Ahmad, Francis, & Zairi, 2007; Grover, 1999; Venkatraman, 1994). Generally IT enables and supports BPC in order to achieve dramatic enhancements in overall performance (Hammer, 1990; Venkatraman, 1994). IT and BPC are interdependent, in the way that the requirements for the new business processes determine the IT resources and capabilities (Venkatraman, 1994). IT capabilities such as flexible IT infrastructure have an impact on IT reliability, which together with IT accessibility impact the overall IT. The successful IT employment and its configuration are achieved by skilled employees with a corresponding IT know-how, which can be enhanced by training and by experiences from past change projects.

1.4 Discussion

With this research, we presented a mixed-method approach for analyzing and integrating the fragmented research on BPC using a qualitative system dynamics methodology. This empirical study has methodological contributions as well as implications for BPC research.

From a methodological perspective, this research contributes to the literature on qualitative methods used in SD, by using case survey methodology as a way to analyze and consolidate variables and their relationships. Since, relationships may be of one or more conditions, such as causal, circumstantial, or contextual, it is the causal that is of interest as the primary building block of causal loop diagram (cf. Yearworth & White 2013). We argue that the application of SD, as a system approach, is suitable method for complex systems such as BPC to start with. Since, SD is capable of creating graspable and remarkably detailed models of influence factors and their relationships. Especially when visualized by means of a causal loop model this makes for a comprehensible representation of BPC project environments. With the empirical CLD presented in this paper, it become apparent that case survey methodology with causal loop model produces results that may not be possible using other methods. We argue that by adopting this mixed-approach; SD modelers that are continuously challenged to deliver models grounded in data can enhance the generalizability and rigor of their models. Even though, we did not explicitly address rigor in our paper, the qualitative data analysis used in this paper, apparently meets both generalizability and rigor needs. We further, argue that more empirical system dynamics models would improve the acceptance of SD modeling as a discipline, which would be of enormous benefit. Also the current lack of system dynamics models in BPC research should make for a fertile ground in the SD community with many practitioners eager to obtain empirically supported SD models as a means of experimentation.

BPC researchers have stated the need for a more holistic understanding of "the context of process change and how process change influences and is influenced by the context" (Grover & Kettinger, 1997). Even though, BPC research field builds on a wealth knowledge derived from a large number of case studies, the insights remained rather fragmented (Jurisch et al., 2013). By adopting case survey methodology with causal loop diagram, as a representation method, we successfully showed how to integrate the fragmented research on BPC to get a more coherent picture. We identify BPC impact variables and elaborate causal links between them by making the abundance of 130 case studies. One of the most frequently coded variable was process efficiency; i.e. that almost 54 percent of all BPC projects resulted in increased efficiency in the organization's processes. By integrating the results of impact variables and their relationships in causal loop diagram, BPC researchers and practitioners will obtain a better understanding of all the factors in the problem. Given these positive implications of SD in BPC research, we expect potential future use of SD in BPC community.

Our findings establish various needs and possibilities regarding future research. The next step in our research is to develop a simulation model. With the help of the simulation model, we want to analyze and understand the consequences of different policy changes in different BPC strategies as well as develop and test different hypotheses, which might enhance the theory of BPC projects.

However, our study shows also few limitations. The first limitation is that the coding process of such a large number of cases is time and resource consuming and requires skilled personnel. It took a couple of months till we reached results. Second limitation refers to a degree of subjectivity, as the coding process; i.e. the identification of impact factors and the elicitation of relationships is bound to a certain degree of personal interpretation. So, to reduce this issue, we first discuss the discrepancies till we reached a consensus. According to Bullock & Tubbs (1990) this helps by reducing individual disparities. Afterwards, we established inter-coder reliability, in order to determine the agreement between the coder. The third limitation is that we cannot guarantee that we found every BPC article published in a literature.

1.5 Conclusion

The focus of this research was to integrate the fragmented research on BPC to identify the impact variables and their causal links. As a means of demonstration and exploration, we designed a causal loop model that captures many relationships gathered through a set of 130 case studies. We successfully showed that case survey methodology is an appropriate method for developing causal loop models. Further, with this research, on the one side, we showed that SD is an appropriate method for complex systems to start with. We thus want to encourage SD researchers to test our approach also in different areas. On the other side, we showed BPC researchers the benefits of system dynamics in BPC area. They can use the proposed CLD model as a starting point for analyzing and understanding BPC factors and their causal links.

2 Consolidating Findings from Business Process Change Case Studies Using System Dynamics: The Example of Employee Morale[5]

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Status	Accepted

Table 6. Fact sheet publication P2

Abstract. In this paper, we explore system dynamics as a useful approach to consolidate findings from case studies on business process change (BPC) projects. We compile data from 65 BPC case studies to develop a system dynamics simulation model that helps us to investigate 'employee morale' as an important construct in BPC projects. We show that such simulation models consolidate the complex and often non-linear findings from BPC case studies in a way that makes it available to discourse among researchers, lecturers and students as well as BPC professionals. Thus, this paper contributes to knowledge management and learning by suggesting system dynamics as a valuable approach to illustrate and convey the complex relationships between important constructs in BPC. This paper also contributes to the domain of business process management by demonstrating the benefits of system dynamics as a way to review and consolidate the abundance of BPC case studies.

[5] Originally published as: Kristekova, Zuzana; Jurisch, Marlen; Schermann, Michael; Krcmar, Helmut: Consolidating findings from business process change case studies using system dynamics: The example of employee morale. Knowledge Management & E-Learning: An International Journal, 4(4), 2012, pp. 455-480

2.1 Introduction

Business process change (BPC) is a pivotal instrument for executives to improve business performance (Hammer & Champy, 1993; Hill & McCoy, 2011; Lopez, 2011). However, BPC projects present risky interventions, which are often fraught with uncertainties, frequent delays and even failures (Hill & McCoy, 2011). Research on BPC offers conflicting findings and suggests a complex and often non-linear nature of BPC projects (Baguma & Ssewanyana, 2008; K. G. Cooper & Reichelt, 2004). The domain of BPC still suffers from a lack of consistent theoretical foundations (e.g., Guha et al., 1997; Huizing, Koster, & Bouman, 1997; Kettinger & Grover, 1995; Teng, Fiedler, & Grover, 1998). In particular, we argue that a plethora of research foci and diverse units of analysis limit the growth of the body of knowledge on BPC.

Lecturers and professionals also struggle with existing BPC training approaches that are frequently based on intuition rather than empirical data (Caulfield & Maj, 2002; Gardiner & Ford, 1980). Traditional education approaches are often not tailored to capture the many complexities of BPC projects. While analyzing a decision, students or managers scan their memory for similar situations, using their cognition to capture current reality and mentally predicting the future state according to available alternatives (Doyle & Ford, 1998; Wang & Chen, 2012). Thus, experience with BPC projects presents the only scarce resource to convey knowledge about BPC (Jurisch et al., 2012).

One way to systematically create experiential learning environments that are grounded in empirical data is through system dynamics (SD) modeling and simulation (Forrester, 1994; Spector & Davidsen, 1997, Spector, 2000). Researchers and practitioners use SD in a variety of use cases that show that SD is suitable to describe, model and convey structure and dynamics of complex systems through modeling feedback loops, delays and uncertainties (Forrester, 1961, 1985, 1992; Senge, 1990; Spector & Davidsen, 1997). Training approaches based on SD lead to high participant awareness and encourage exploration through the ability to modify and replay the models (Madachy, 2008). For instance, experimenting with dynamic graphs enables training participants to understand important effects, relationships and complex feedback loops in BPC projects more effectively as is the case with traditional lecture formats (Yamamoto, 2010; Vergidis, Tiwari, & Majeed, 2006; Xirogiannis & Glykas, 2004).

The goal of this research is to explore the usefulness of SD for consolidating the findings from case studies and conveying the structure and dynamics of BPC projects. By eliciting impact factors and their mutual relationships from BPC projects, we aim to increase transparency of causal links and effects within these projects, thereby enhancing practitioners' abilities to anticipate and cope with these phenomena. This leads us to the following research questions:

- Which impact factors and relationships have to be considered for a SD simulation model for BPC projects?
- What are the benefits and limitations of SD for BPC learning offerings?

In order to demonstrate the use of SD for simulating certain developments in BPC projects, we develop a SD simulation model for managing and understanding employee morale when changing a business process. The proposed SD simulation model focuses on employee morale, since several researchers consider "employee morale" a pivotal variable determining the success of BPC projects (Grover, 1999; McAdam & Donaghy, 1999). Simultaneously, research also asserts that employee morale is affected by many relationships, which might have non-linear characteristics that make it particularly difficult to manage and forecast. In general, we follow the guidance of Baguma & Ssewanyana (2008) when developing our SD simulation model. As SD models are limited by the extent of available empirical data, we thus extend the guidelines for SD by grounding our simulation model in case studies of BPC projects published in research literature. In doing so, we explore a novel source of empirical data required for SD simulation models (Morecraft, 1982).

We contribute to the domain of BPC by making the abundance of case studies on BPC projects available to SD modeling. In doing so, we present SD models as a novel approach to review and consolidate the complex and often non-linear findings from BPC case studies. This paper also contributes to the domain of knowledge management and learning by suggesting SD as a valuable approach to illustrate, explain and convey the complex relationships between important variables in BPC projects. We hope to inspire researchers and practitioners to use SD as an effective instrument that makes the complex nature of BPC projects available to discourse among researchers, lecturers, students and BPC professionals.

The remainder of the paper is organized as follows. In section 2.2, we review the literature on BPC and system dynamics. In section 2.3, we outline our research design and explain the problem statement, data collection and causal loop modeling. In section 2.4, we detail our SD simulation model and demonstrate the use of it for managing employee morale in BPC projects. We discuss our results and limitations in section 2.5 and conclude the paper with an outlook on future research opportunities in section 2.6.

2.2 Literature Review

2.2.1 Business Process Change

BPC has its roots in Business Process Reengineering (BPR) and Total Quality Management (TQM). Hammer and Champy (1993) define BPR as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures such as cost, quality, service and speed. BPR, business process innovation (BPI) or business process transformation (BPT) are frequently used synonymously for the same phenomenon. According to Grover and Markus (2008) these variations in name of essentially the same concept were part of a bandwagon effect. All BPR, BPI and BPT projects are radical, revolutionary and one-time undertakings (Davenport, 1993; Hammer, 1990; Grover & Markus, 2008), TQM is considered to be an integrated and more evolutionary approach for process improvement (Bucher & Winter, 2007). Furthermore, TQM aims at improving quality of products and services in all departments and functions (S. Koch, 2011). While both approaches BPR and TQM share the common goal of improving processes, they are also frequently used complementary (Grover & Markus, 2008).

Against this background, BPC can be viewed as a management concept that involves any type of process change – revolutionary (radical) or evolutionary (continuous) (Grover, Kettinger, & Teng, 2000; Grover & Markus, 2008). Figure 13 illustrates the central elements of BPC.

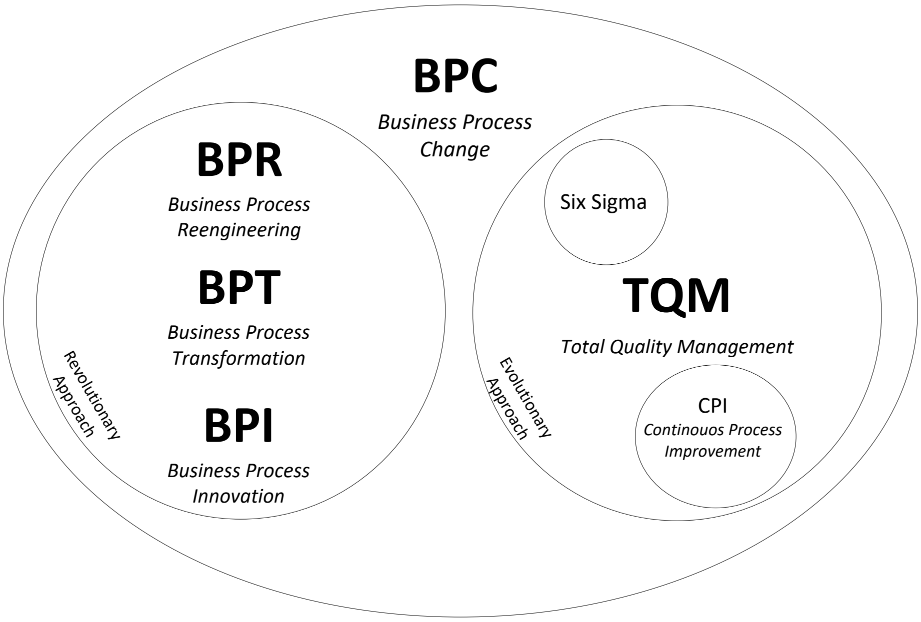

Figure 13. Central elements of business process change

2.2.2 Business Process Change Success Factors

Over the last two decades, the success of BPC has been studied through several theoretical and practical lenses. Two dominant streams of research can be identified. The first group of researchers (e.g., Grover, 1999; Guha, Grover, Kettinger, & Teng, 1997; Kettinger & Grover, 1995) address the topic of BPC primarily from an organizational change perspective, while more recently a second group of researchers (e.g., Grover, Teng, Segars, & Fiedler, 1998; Melville, Kraemer, & Gurbaxani, 2004; Radhakrishnan, Zu, & Grover, 2008) analyse the impact of IT investments on organizational performance from a process-oriented perspective.

The most prominent models analysing the critical success factors for BPC (i.e., Grover, 1999; Guha, Grover, Kettinger, & Teng, 1997; Kettinger & Grover, 1995) share the same assumption, namely, that successful BPC is strategy-driven. In this respect, BPC is always a strategic change (Guha, Grover, Kettinger, & Teng, 1997). Top management holds a key role in supporting the respective strategic change initiative while also encouraging a change-ready organizational culture (Kettinger & Grover, 1995; Skerlavaj, Stemberger, Skrinjar, & Dimovski, 2007). Often this is referred to as establishing an innovative organizational environment, which assumes a central role in most BPC models (Guha, Grover, Kettinger, & Teng, 1997; Kettinger & Grover, 1995).

The success of BPC also depends on the quality of the implementation process (Trkman, 2010). Therefore, BPC needs to be accompanied by change management to ensure joint efforts between managers and employees. Grover (1999) argues that a lack of change management inhibits the success of BPC projects with respect to processes and people factors. Bearing this in mind, it is no surprise that all BPC models (e.g., Grover, 1999; Guha, Grover, Kettinger, & Teng, 1997; Huizing, Koster, & Bouman, 1997; Kettinger & Grover, 1995) propose an alignment of process and change management practices, along with the change environment, in order to improve business processes and obtain measurable and sustainable competitive performance gains.

Huizing, Koster, & Bouman (1997) add an interesting perspective to common BPC research models: the concept of fit and organizational performance in change projects. Their framework distinguishes five dimensions: level of ambition, breadth, depth, planning and coordination of the change process. Based on thorough empirical verification of their research framework with 90 organizations Huizing, Koster, & Bouman (1997) conclude that the ambition for change has to be balanced with the organization's ability to change. They further identify that "the higher the level of ambition, the larger the number of critical activities […] that need to be tackled and the more organizational aspects that have to be changed […]" (Huizing, Koster, & Bouman, 1997, p.112). Even though theoretical and practical evidence highlights the importance of the dimension level of ambition or project scope, none of the prominent BPC models (i.e., Guha, Grover, Kettinger, & Teng, 1997; Kettinger & Grover, 1995) incorporate it as a critical success factor for BPC.

The employment of the IT dimension and its relation to BPC success has produced contradicting results. While some researchers argue that IT poses an important catalyst and enabler for BPC (Trkman, 2010), others argue that IT may not necessarily be a critical success factor for BPC (Grover, 1999; Guha, Grover, Kettinger, & Teng, 1997; Kettinger & Grover, 1995). Besides the ongoing debate on the business value of IT, the effect of IT on business performance has in fact often been contested (Karimi, Somers, & Bhattacherjee, 2007; Radhakrishnan, Zu, & Grover, 2008). For instance, the relationship between IT investment and firm performance through an input-output perspective is well described in production function and process-oriented models (Melville, Kraemer, & Gurbaxani, 2004). Particularly, process-oriented models offer helpful insights on how IT can provide business value through the use of business processes. Soh and Markus (1995) introduced a conceptual framework which posits that IT investments lead to IT assets (IT conversion process), IT assets to IT impacts (IT use process) and IT impacts to organizational performance (competitive process). Melville and colleagues (2004) also introduce a process-level model, which depicts that IT resources and complementary organizational resources have to be combined into a business process which than yields business process performance. Recently, Trkman (2010) has argued that the value of IT for successful BPC should also be measured at process level, since the prime effects of IT are in fact expected to be realized at process level (Melville, Kraemer, & Gurbaxani, 2004).

The short summary of existent research on the topic of BPC success shows that their research outcomes produced to some extent conflicting results and few reliable generalizations. Till today, none of the proposed success factor models for BPC (e.g., Guha, Grover, Kettinger, & Teng, 1997; Huizing, Koster, & Bouman, 1997; Kettinger & Grover, 1995; Teng, Fiedler, & Grover, 1998) managed to prevail. Grover and Markus (2008) stated that the field of BPC still suffers from a lack of knowledge on adequate theories and methods. This lack of knowledge is also evident in prominent BPC models and leads to the following shortcomings. First, the majority of research models for BPC success are rather atheoretical (i.e., Karimi, Somers, & Bhattacherjee, 2007; Kettinger & Grover, 1995; Teng, Fiedler, & Grover, 1998). Most of them fail to evaluate the identified BPC success factors from different theoretical angles. Second, another group of researchers makes theoretical assumptions on only specific causal relations, e.g., impact of IT or change management on BPC success (i.e., Grover, Teng, Segars, & Fiedler, 1998; Huizing, Koster, & Bouman, 1997), which sometimes stand isolated in the overall context of BPC success. Third, some research models on the topic of BPC success stem from only one or few case studies in domain specific settings (i.e., Caron, Stoddard, & Jarvenpaa, 1994; Larsen & Myers, 1997), thus limiting the generalizability power of these research results. More so, the level of granularity in which the various BPC success factors and their relations are presented renders it difficult to derive a detailed causal loop or SD simulation model for BPC success.

2.2.3 System Dynamics for Business Process Change

To minimize the impact of BPC failures and to address these complexities, simulation has been proposed as one of the techniques suitable for the support of BPC (e.g., Spector & Davidsen, 1997; Kettinger, Teng, & Guha, 1997; Hlupic, de Vreede, & Orsoni, 2006; Jahangirian, Eldabi, Naseer, Stergioulas, & Young, 2010). Shannon (1975) defined simulation as the process of designing a model of a real system and conducting experiments with this model for the purpose, either of understanding the behavior of the system or evaluating various strategies. One popular simulation technique is system dynamics (Greasley, 2009).

SD is a methodology used for the analysis of the behavior of complex systems. SD is a rigorous approach in capturing interrelationships among variables and in handling dynamic aspects of the system behavior (Sterman, 2000). SD attempts to understand why things happen by identifying the structure behind the behavior, using the idea of system archetypes to describe recurring structures in systems (Greasley, 2009). SD is strongly related to systems thinking (Senge, 1990), which states that structure determines behavior. So changing the business system's structure means changing the behavior of the system and thus changing the future of a company (Ashayeri, Keij, & Broecker, 1998). SD is divided into two stages, qualitative and quantitative analysis. In the first stage, modelers identify system variables for the problem in concern and develop a qualitative system model in the form of a causal loop diagram (CLD). In the second stage, the qualitative model is transformed into a system flow diagram and is calibrated for quantitative analysis using computer simulation (Quaddus & Intrapairot, 2001). The results of such simulations can help organizations in forecasting, solving problems and developing policies (Baguma & Ssewanyana, 2008). Over the years, SD has been applied to many areas such as supply chain management (e.g., Anderson, Morrice, & Lundeen, 2003; Spengler & Schroeter, 2003; Akkermans & Dellaert, 2005), project management (e.g., Park & Pena-Mora, 2003; Lyneis, Cooper, & Els, 2001; Taylor & Ford, 2006), change management (e.g., Eden, Williams, & Ackermann, 1998; Howick & Eden, 2001; Cooper & Reichelt, 2004) and BPC (e.g., van Ackere, Larsen, & Morecroft, 1993; Ashayeri, Keij, & Broecker, 1998; Burges, 1998; Baguma & Ssewanyana, 2008). Surveying all of these works is beyond the scope of this article. Thus, we focus here on articles dealing with BPC.

One of the early applications of SD in BPC was by van Ackere, Larsen, & Morecroft (1993). The authors explore the link between SD simulation and business process redesign. For their analysis they selected a classic well-known logistical system – a multi-stage production and distribution system - also known as the 'beer game'. The model of the beer game shows the major processes graphically and how they are linked within an organization. With their work they illustrate changing concepts and tools in action. Ashayeri and colleagues (1998) applied the SD simulation approach to develop a conceptual framework for conducting global BPC; i.e. restructuring processes in all functions considering customer value. They established a clear link between criteria that are important to customers (external criteria) and performance measures for internal usage (internal criteria), in order to quantify the customers' requirements and preferences. Their framework combines concepts of SD and analytical hierarchy process (ANP). With the help of ANP managers can structure the problems in a top-down way and break them down in elementary sub-problems. With the help of the SD simulation model, they can simulate which business system components will result in the highest improvement and help a company to change toward its vision. Other related applications include the work of Burges (1998) who proposes a generic SD simulation model of an organization undergoing a BPC project, which is rooted in the operations management literature. The model depicts both organization and BPC as a single process. With his modeling perspective he is focusing on competitive capabilities such as quality, cost, time and flexibility. However, the main focus is on benefits derived from cost reduction. Baguma and Ssewanyana (2008) use SD simulation model for investigating the impact of IT infrastructure on BPC. Their simulation model is based on data collected from five commercial banks. With the help of the SD simulation model they test different hypothesis and found that the role of network infrastructure is critical for improving business processes and enhancing customer services.

2.2.4 System Dynamics in Management Training and Education

Over the years, many SD simulation models have been converted into business game simulations for the use in management training and education. For example, Graham and colleagues (1992) suggest a combination of SD simulation models with conventional case studies to create learning environments for management education. They argue that model-supported case studies bring improvement in strategic thinking skills. They present two examples to show explicitly how cases and SD simulation models are combined and used in management education. With their work they focus on: (1) how to teach effectively inquiry skills, (2) how to teach conceptualization skills and (3) how to enhance the ability to transfer insights into new situations. Sioutine and Spector (1999) present a SD simulation model for large-scale instructional development projects. With their learning environment the authors attempt to develop users' appreciation and understanding of the many dynamic factors involved in project planning and resource allocation, especially those pertaining to how project teams are optimally organized. Thus, managers and students learn the important factors for managing projects successfully. Barlas and Diker (2000) develop an interactive SD simulation model (UNIGAME) with the focus on academic aspects of university management. The model captures long-term, dynamic, strategic management problems, such as growing student and faculty ratios, poor teaching quality and low research productivity. Students and managers can analyze and test alternative management strategies. The results of their study show that the proposed game is a useful technology to support strategic decision-making and a laboratory for theoretical research on how to best deal with strategic university management problems. Baume (2009) develops a SD simulation model as a strategic game (Go4C) for practical training with students and managers. The simulation game deals with the complex interrelationships of IT decisions and corporate strategy of a bank. Four players of one group assume the roles of chief information officer (CIO), chief financial officer (CFO), chief marketing officer (CMO) and chief operating officer (COO) and make decisions about projects and business ratios. The simulation game stresses along strategic decisions the communication between the four players of one group.

Surveying the articles, we found that literature provides a range of examples that make use of SD simulation for strategy or hypothesis testing, or for management and educational training. However, many of these models vary widely in the level of detail provided and their structure. Also, in our review, we did not identify learning tools for conducting BPC projects available that would adequately help practitioners in fully comprehending the important parameters of BPC projects that are grounded in empirical data.

2.3 Research Design

Our research applies a SD approach as the framework for analysis, model building and simulation (Baguma & Ssewanyana, 2008). This was a process that covered: problem statement, meta-case analysis, conceptual model, SD model building and scenario planning.

2.3.1 Problem Statement

To illustrate the topic of employee morale in BPC projects, we utilize a standard SAP reference business process (“sales process”) (Konstantinidis et al., 2012). In order to reengineer the process, we first describe the process and determine its weak spots (Figure 14). The weak spots in the process are labeled with flash sign.

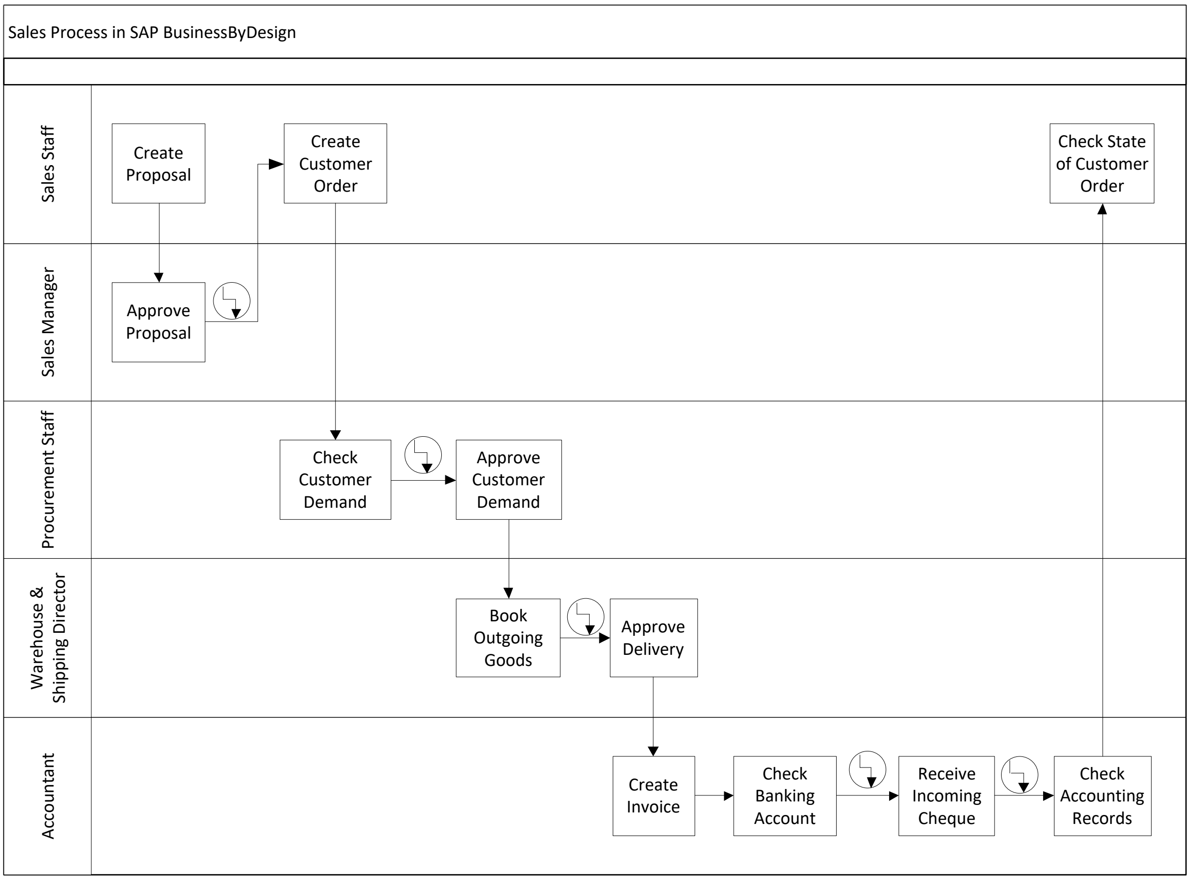

Figure 14. Sales process

The sales process consists of four sectors: sales, procurement, warehouse and shipping and accounting. In the beginning the sales staff creates a proposal for the customer and checks if the products are available at the agreed date and records the desired delivery date on all subsequently produced documents. The produced documents are sent to the sales manager for an approval. After the approval the sales staff creates a customer order on the basis of the proposal. In the next step the procurement staff reviews the customer demand generated by the order. When the review was successful, procurement staff approves the demand. Subsequently, the warehouse and shipping director books the outgoing goods and the system creates the delivery automatically. Afterwards the warehouse and shipping director has to approve the delivery and print the shipping order. Based on the delivered customer order the sales staff creates a customer invoice. Then the accountant verifies the customer account and the booking, which were created during the process. If the accountant receives the check, it will be entered to balance the open items. The accountant always checks the accounting records, which are created during the process. The sales staff can monitor the state of the order any time during the document flow.

The initial situation shows that the sales process is shaped by many prove steps because of the fragmentation of the information. Such fragmentation of information involves several feedback loops in the process. However, when information is incomplete or corrupt, or when it changes, the feedback loops become very time consuming in the process. They cause higher rework, increase the work backlog, result in greater time pressure and finally negatively influence the employee morale.

Therefore, the initial situation in this reference sales process raises a fundamental question – how much emphasis should be placed on reducing these time-consuming process steps with respect to employee morale? Hence, employee morale was adopted as the dependent variable of this study.

2.3.2 Meta-Case Analysis

To answer the aforementioned question, we conducted a meta-case analysis, also referred to as structured content analysis of cases (Jauch, Osborn, & Martin, 1980) or case survey (Larsson, 1993; Lucas, 1974; Yin & Heald, 1975). The meta-case analysis method turned out to be particularly useful for our research due to the following criteria proposed by Larsson (1993): (1) the research area comprises a huge number of case studies (i.e., cases of BPC projects) (Yin & Heald, 1975); (2) the unit of analysis is the organization (i.e., the organization conducting the BPC project) (Jauch, Osborn, & Martin, 1980); (3) a broad range of impact factors is of interest (Jauch, Osborn, & Martin, 1980); and (4) it is difficult to do structured primary research across cases in this research domain.

Sample collection

For the case sample collection, we applied a detailed screening of literature. We used the key words “business process”, “business process change”, “business process reengineering” and “business process transformation”. After the initial literature screening, we identified more than 5,000 references for each combination of key words and the term “case study”. These were found through traditional channels (e.g., libraries), conference proceedings, online database services (e.g., Emerald, EBSCO, Science Direct and Google Scholar), consulting journals and other web search tools. To determine the relevance of these articles, we further explored titles, abstracts and keywords. After this step, the identified 5,000 references were further reduced to 217 case studies. Next, we excluded case studies with the following attributes: (1) none or very little information about the case; (2) none or very little information about the impact factors for the success of the BPC initiative; and (3) focused on the technology, not on the BPC initiative. After eliminating these case studies we reached a final sample of 65 case studies, comprising 46 journal articles, 13 book sections, 2 conference articles, 3 theses and 1 working paper. The final sample consists of a wide set of international BPC initiatives, 43 in private and 22 in public organizations. The articles span the years 1993 to 2010 and have an average length of 14 pages.

Data collection

The coding scheme “documents and guides the conversion of qualitative case study data into quantified variables” (Larsson, 1993) and thus stands as the core element of a meta-case analysis. We designed the coding scheme in the following manner. First, we defined the variables related to managing employee morale in BPC projects including their objects for our research. In line with Larsson (1993), our coding scheme comprises variables that represent the aspects of the study design (e.g., training rate, hiring rate, leaving rate), the publication status (e.g., ranging from journal article to book section) and control variables relevant to the studied phenomenon (e.g., the size of the BPC project).

Data coding

As a result, a master list of the variables evolved, which we employ for the frequency coding. The frequency coding of the variables and their interrelationships is based on the methodology proposed by Lacity et al. (2010). Following this methodology, we analyzed how often a variable occurred in a case study and coded and accumulated the frequency of each variable. Afterwards, we empirically examined the relationships between the variables and assigned two possible values: '+1', '-1'. We coded '+1' for positive relationships, '-1' for negative relationships. However, all relationships we coded have a positive influence on employee morale.

To ensure consistent coding at the outset, we established inter-coder reliability. The results indicate a Krippendorf's Alpha of 0.68, which is an acceptable inter-coder reliability (Krippendorf, 1980).

2.3.3 Data Analysis

Analysis of the dependent variable

We coded the dependent variable 'employee morale' 27 times in our set of case studies. Employee morale refers to the degree to which employees feel comfortable in their current roles and responsibilities and that the workload is adequate to their skills and responsibilities. Employee morale also refers to the level of involvement of employees in decision making (Paper, 1997). Some change projects seek to empower the employees to achieve higher employee morale (Stemberger, Kovacic, & Jaklic, 2007), others try to improve employee morale by "changing responsibilities from routine transaction processing to value-added accountability" (Ballou, 1995, p.23). High employee morale is especially important as satisfied employees are able to generate higher value (Newman, Cowling, & Leigh, 1998).

Analysis of impact factors on employee morale in BPC research

Based on our set of 65 case studies, we identified 18 impact factors on employee morale used in BPC research (Table 7). We counted the frequency of the words and their synonyms. As some words may have multiple meanings, we always counted the word-frequency in the whole sentence context. We sorted these impact factors by frequency of use.

#	Identified impact factors on employee morale	Frequency
1.	Customer satisfaction	58
2.	Management support	48
3.	Training	45
4.	Quality of products and services	45
5.	IT resources	42

6.	Governance structure	40
7.	Measurement for controlling and monitoring business processes	40
8.	Management vision/understanding	39
9.	Change understanding	32
10.	Reduction of cycle time	31
11.	Cost reduction	30
12.	Performance measurement	28
13.	Availability of process management methods & tools	27
14.	Management resource support	18
15.	Productivity	18
16.	IT capability	15
17.	Organizational learning capability	11
18.	BPM methods & tools capability	7
	Total	*574*

Table 7. Frequency of impact factors on employee morale

Analysis of relationships between employee morale and BPC variables

In this section, we summarize the findings on the 27 relationships we coded between employee morale and their impact factors (Table 8). We aggregated some of the findings into broader categories, as according to Forrester (1976) phenomena with similar structures may be aggregated together. We treated all coded relationship-frequency as significant, as also relationships coded only once may have a significant impact on employee morale.

The coding results show that employee morale is not straightforward to analyze. Not only impact factors influencing employee morale must be taken into consideration but also the interaction between these impact factors. These relationships are outlined in the conceptual model (Figure 15).

Dependent variable	**Employee morale**
Impact factors on employee morale	*Number of frequency*
Productivity	3
Management vision/understanding	2

Customer satisfaction	2
Training	1
Reduction of cycle time	1
Cost reduction	1
Quality of products and services	1
Governance structure	1
Resources	
IT resources	3
Process management methods & tools	1
Performance measurement	
Measurement for controlling and monitoring business processes	3
Performance measurement	1
Management support	1
Management support	1
Management resource support	1
Skills and capabilities	
BPM methods & tools capability	2
IT capability	1
Change understanding	1
Organizational learning	1
Total	27

Table 8. Relationships between impact factors and employee morale

Conceptual model

During this process step, a conceptual model of the problem, known as a causal loop diagram (CLD) was created (Figure 15). The CLD model is based on the previous step 'data coding' and captures the interactions and relationships between the identified variables. CLD is a representation that consists of variables connected by arrows denoting the causal-and-effect relationships among the variables (Madachy, 2008). Causal relationships support the clarification of the actual structure of the examined problem, as the clear picture of the problem's structure improves understanding of the observed phenomena (Forrester & Senge, 1980). Moreover, Schwaninger & Hamann (2005) state that propositions regarding causal relationships need to be carefully examined by drawing on additional theoretical or empirical data. Causally related variables indicate how the dependent variable behaves when the independent variable changes (Sterman, 2000). In CLD this behavior is represented with the help of positive or negative signs. For more detail on CLD, we refer to Sterman (2000).

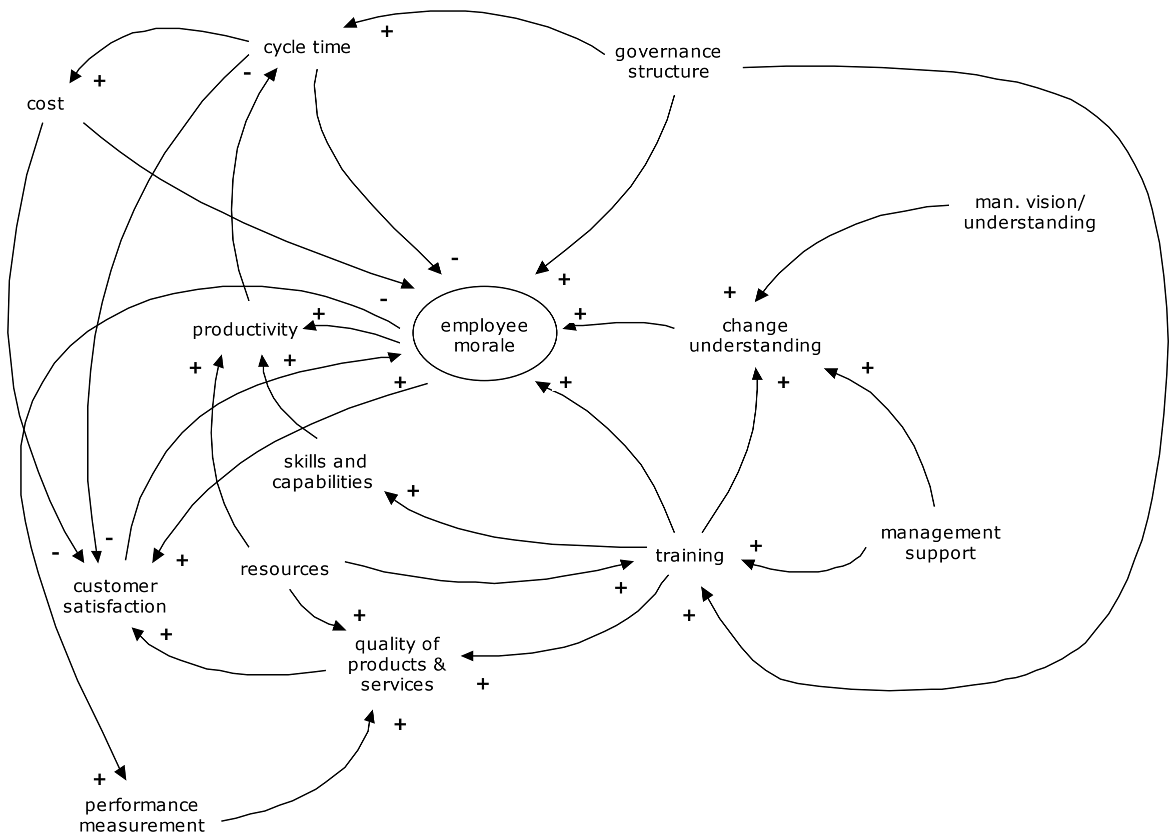

Figure 15. Causal loop model of relationships between impact factors and employee morale

The first factor in Figure 15 that influences employee morale represents the factor management vision or understanding, which is represented through an indirect link from the factor change understanding. As Stemberger, Kovacic, & Jaklic (2007) found, a clear management vision enables employees to better understand the project goals or project changes, which in turn has a positive effect on employee morale and commitment (Harvey, 1994). Hammer and Champy (1993) noticed that management support also positively influences employee change understanding and consequently positively influences employee morale. The factor change understanding is furthermore affected by training; i.e. training represents one method to prepare employees for the change.

Training represents another important factor influencing employee morale, especially when employees gain new skills for the changed processes and tasks (Newman, Cowling, & Leigh, 1998). Furthermore, successful training enhances employees' skills and capabilities; i.e. skilled employees are capable to support and transform the organizational vision (Albizu, Olazaran, & Simon, 2004). Training has also an essential positive impact on the quality of the products and services (Newman, Cowling, & Leigh, 1998). The results of higher quality are satisfied customers (Thong, Yap, & Seah, 2000); i.e. the enhancement of the quality also positively influences employee morale, in the model represented by an indirect link from customer satisfaction. The factor resources presents one of the most significant factors that impact quality (Harvey, 1994; Geier, 1997; Newman, Cowling, & Leigh, 1998). Along with resources and training, performance measurement positively influences the quality of products and services (Dignan, 1995; Jackson, 1995) and has an indirect positive effect on customer satisfaction and employee morale. In turn, positive employee morale causes that performance measurement is performed more efficiently (Harvey, 1994).

Productivity is another important factor in this model. This factor is strongly affected by employee morale. Especially, committed and motivated employees have a significant impact on productivity (Proctor & Gray, 2006). Other factors influencing productivity are skills and capabilities and resources. In turn, productivity influences the cycle times; i.e. when productivity is low it results in higher cycle times and vice versa. Such effects are illustrated by a minus sign in the model. Subsequently, cycle time influences employee morale, e.g. if cycle times are reduced then employee morale increases. Similarly to cycle times, the reduction of cost plays an important role by influencing employee morale and customer satisfaction (Weise, 1996); i.e. if employees drive the costs down, e.g., through reduction of cycle times, then employee morale and customer satisfaction increase.

The factor governance structure positively impacts employee morale. It implies that a formalized governance structure is used for the project as opposed to the existing structure of the organization (Huizing, Koster, & Bouman, 1997). Working in a team results in higher employee morale (Harvey, 1994).

2.4 System Dynamics Simulation Model

2.4.1 System Dynamics Model

SD modeling refers to a mathematically formalized version of a theory. The proposed SD model is based on the conceptual model; i.e. on the CLD, elaborated in the previous step. The proposed SD model focuses on capturing the physical flows and decision-making processes carried out by the business game players. The physical flows represent stocks, which are natural accumulations with physical meaning and are invariably specified by quantitative measures. An example of the physical flow in a model of a human resource department includes a certain average lag in headcount required to accomplish the projects tasks. On the other hand, the decision-making rules include procedures for determining hiring or downsizing goals, or changes in price. Physical flows are relatively easy to capture, whereas to model the decision making processes of the participants is considerably harder (Sterman, 1987). Therefore, we use heuristics while modeling such decision-making rules, as proposed by Sterman (1987).

The whole SD model as depicted in Figure 16 describes the dynamics of employee morale. It is based on the identified variables and their interactions as introduced above. The SD simulation is carried out with the Powersim software in version 8, which is capable of modeling system dynamics. We use several arrays to replicate the model structure without having to duplicate the model, in order to implement all four sectors from the sales process. The model data are based on several assumptions: (1) the new hired employees are only half as productive as experienced employees and (2) graduate into experienced employees only through training;

(3) each month 5% of employees leave the project; (4) employee morale is set to 72% and customer satisfaction is set to 85% at the beginning of the BPC projects; (5) for other variables such as the number of experienced employees, or costs for employees and other resources we use sample values that can be modified by the user in the management dashboard at the beginning of the SD simulation. The management dashboard is designed as the user interface to the SD simulation for access to model parameters and model settings without modifying the actual model's equations. The effect factors between data interaction; i.e. the behavioral repercussions of a change in one variable to another, are gathered from the 'CIO business game' (Baume, 2009), which relies on real empirical project data.

The core variable 'emp_morale', represented as a stock in the model, changes its current value by adding the value of inflows and subtracting the value of outflows. The inflow 'emp_morale_rate_in_delta' accumulates the effect of the variables: 'time_spent_in_training', 'customer_satisfaction', 'BPC_cycle_time', 'cost_total' and 'governance_structure'. Any change in these variables produces an increase or decay in 'emp_morale' by a fraction of 0.005. The variable 'time_spent_in_training' increases 'emp_morale' when the time spent in training is above 10% otherwise 'emp_morale' is decreased. If 'customer_satisfaction' drops below 80% then 'emp_morale' drops as well. Increase in 'BPC_cycle_time' causes a decrease in 'emp_morale'. The variable 'BPC_cycle_time' is dependent on productivity, which utilizes the effect of error generation and the number of employees available for the BPC project. Adding the feedback from 'cost_total' to 'emp_morale' captures the costs for employees and other resources. If the costs exceed the current earnings, 'emp_morale' will decay. The variable 'governance_structure' utilizes the variable 'man_emp' that represents the number of managerial personnel needed for BPC projects to supervise effectively. A gap in the managerial personnel drops the employee morale. The second inflow rate 'emp_morale_rate_in' captures the effect of change understanding. The variable 'change_understanding' captures the impact of change in amount of employees by multiplying the number of experienced employees by employee morale and the number of new employees by their start morale value. The outflow rate 'emp_morale_rate_out' is used to reach equilibrium in the dependent variable; i.e. the outflow rate uses 'emp_morale' as input variable.

The variable 'error_generation' is dependent on the amount of time spent in training and on employee morale. It ascends or descends by a fraction of 0.04 multiplied by the time spent in training and subtracted from a common error generation, in this case by 0.2, when time spent in training remains zero. The second variable employee morale uses the same fraction rate and increases error generation when it drops under 70%. The effect of error generation on quality is simply its reverse function, which is implemented as 1-error_generation. Quality and employee morale effects customer satisfaction by using the same fraction rate; i.e. 0.04.

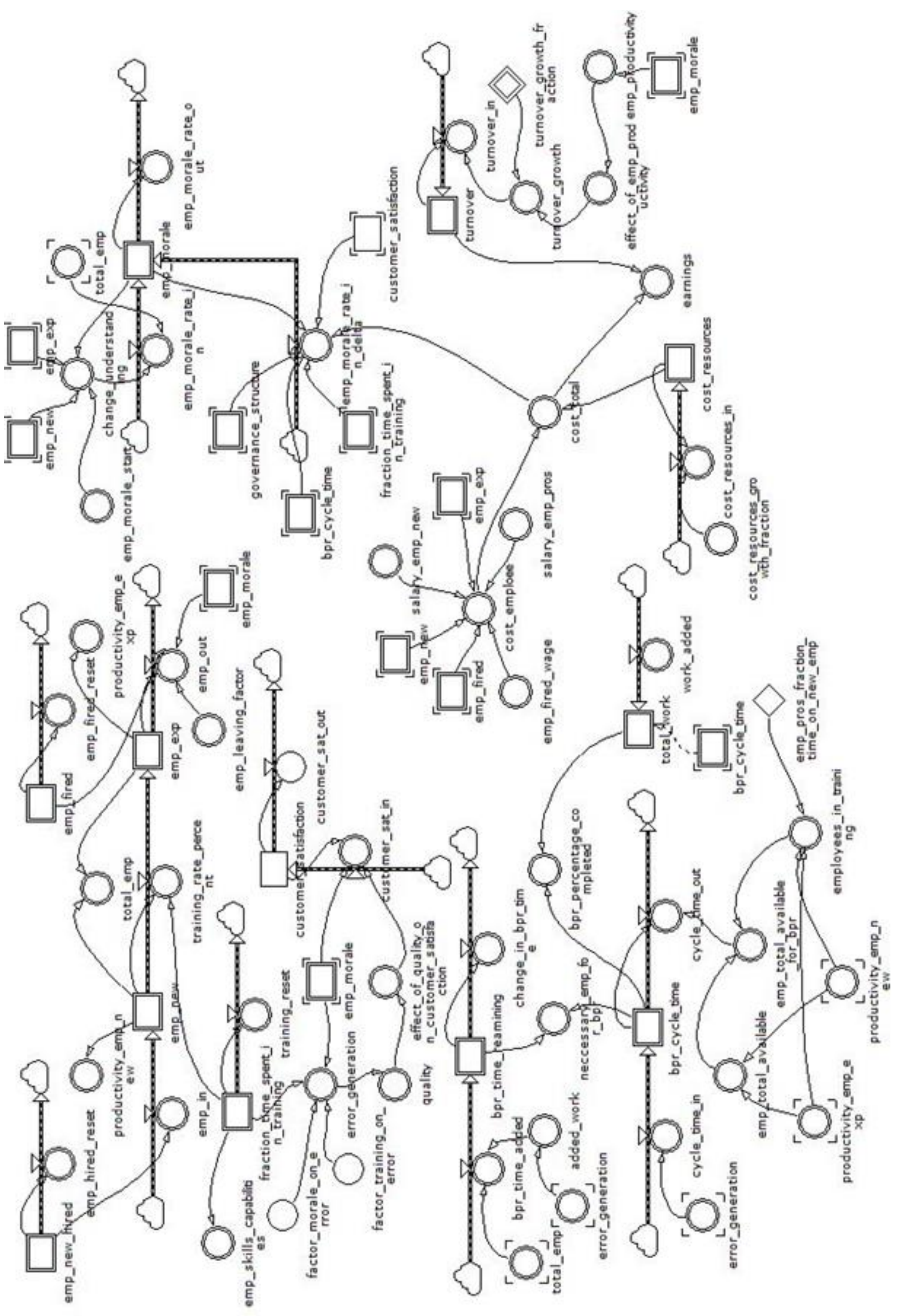

Figure 16. System dynamics simulation model

2.4.2 Scenario Planning

For the scenario planning, we formulate two heuristics for the case "managing employee morale in BPC projects", as with the help of heuristics it is easier to understand the decision making processes of the participants (Sterman, 1987):

1. The first heuristic refers to the comparison of the average skill level of the employee with the desired average skill level needed for the project. If employees perceive their assignments as too easy and tiresome, their overall morale will decrease. At the same time, if the task is too challenging, the employees may become frustrated and the morale will drop as well. This might also impact overall team morale. Thus, the goal is to adjust the actual skill level of the employee towards the target skill level needed for the BPC project.
2. The second heuristic refers to the reduction of cycle times. It involves the reallocation of decision-making and responsibility downwards the organizational hierarchy, granting employees the ability to affect process outcomes. Giving employees the chance to act on their own might result in several positive implications in the process outcome, such as increased efficiency in employees because of increased ownership in their work, increased productivity, reduced costs, job satisfaction and increased employee morale. Thus, the goal is to provide a positive management support (e.g., trust, authenticity) regarding responsibility for own output.

2.4.3 Scenario 1. Reduce work cycles by accelerating the training for new employees

For the SD simulation experiments, we took a base case scenario from SAP for the sales process. It shows that there is a total rework of 384 tasks or 1.92 (384/200) tasks per employee and 72% employee morale. Furthermore, at the beginning new employees are only half as productive as experienced employees and new hired employees are more likely to generate errors, as they do not have the desired skill levels. Therefore, too many new employees on a task decrease the overall employee productivity by introducing errors in their tasks, which must be reworked at a later date. However, expecting less error generation and decrease in amount of rework cycles without providing corresponding training would be unfeasible. Newly hired employees transform into experienced employees only through training overhead. Thus, the question that arises in this scenario is how a unit increase (e.g., an increase of 5%) in skill level of employees would change the rework and morale pattern. In the first SD simulation scenario, we therefore analyze the impact of accelerating the training for newly hired employees in order to reduce the rework cycles arising from error generation due to the lack of desired skill levels.

By simulating scenario 1, the results show that if we consider accelerating the overall training of new employees, e.g., a stepwise increase from 5% to 35% per month, then the new employees graduate faster into experienced employees. Moreover, the overall error generation rate is decreased from 0.098 to 0.065; i.e. an improvement of approx. 32.3%. As error generation is compounded with rework cycles, we observe that when error generation is below 7%, then the rework cycles are reduced by 28%; i.e. a total rework of 556.5 tasks (2.9 tasks per employee) and the employee morale is increased from 68% to 93%; i.e. an increase of 37% (Figure 17). Compared to the base scenario this is a significant improvement.

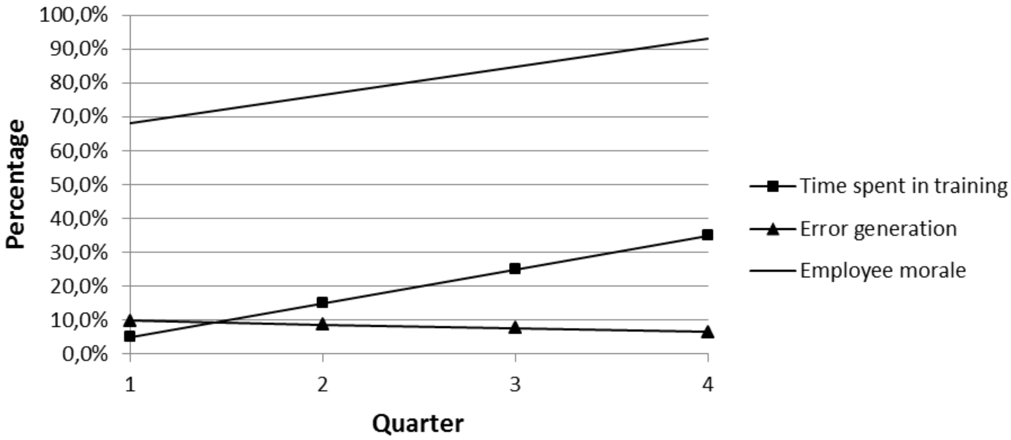

Figure 17. SD simulation results from scenario 1

However, if we increase the time spent in the training above 60%, this produces a lag in the desired workforce; i.e. the employees are not able to accomplish the work. This results in employee tediousness and influences negatively the employee's morale. As the SD simulation results show an increase in training above 60% leads to a total rework of 442 tasks (2.21 tasks per employee) and a 23% decrease in employee morale. In addition, if employee moral falls below 65%, the attrition rate is increasing. In comparison to the base scenario there is an overall deterioration.

Based on the SD simulation results, we can conclude that training overhead between 30%-60% has a positive impact on employee morale and on overall productivity. Both factors lead to a positive change in the rework pattern. We can also add that if the time spent on trainings falls below 30% then the overall employee morale is decreasing, as employees feel most likely disappointed that their company is not investing in them. Furthermore, if the time spent on trainings exceeds 60%, employee morale is decreasing as well, since the extensive trainings reduce the time available to complete actual work; i.e. too many employees must interrupt their daily tasks and assist in the training process of new employees. This causes increased cycle times, delays on time deliveries and increases the time pressure on employees.

2.4.4 Scenario 2. Shorten the approval process

In the current sales process, many process steps are filled with checking and controlling activities. For example, the sales staff always needs to send the created proposal to the sales manager for approval. Establishing such non-value added controls and approval activities along a process increases process duration and cost. Employees who perform the process steps are not permitted to make decisions on their own. Instead, they need to consult a superior in order to obtain approval. However, if the organization or a manager holds a positive attitude toward employees' reliability and goodwill in a different decision situation, employees' performance and morale is positively influenced (Lämsä & Pucetaite, 2006). Nonetheless, some employees feel overwhelmed, if they need to take the responsibility for the decisions by themselves – especially, when the decision is compounded by a certain amount of money. With respect to this issue, we decided to add a certain threshold unit and leave the decision to the sales staff only if the value of the proposal is below this threshold unit. Thus, the question that arises in this scenario is how a shortening of the approval process would change the rework and morale pattern (Figure 18).

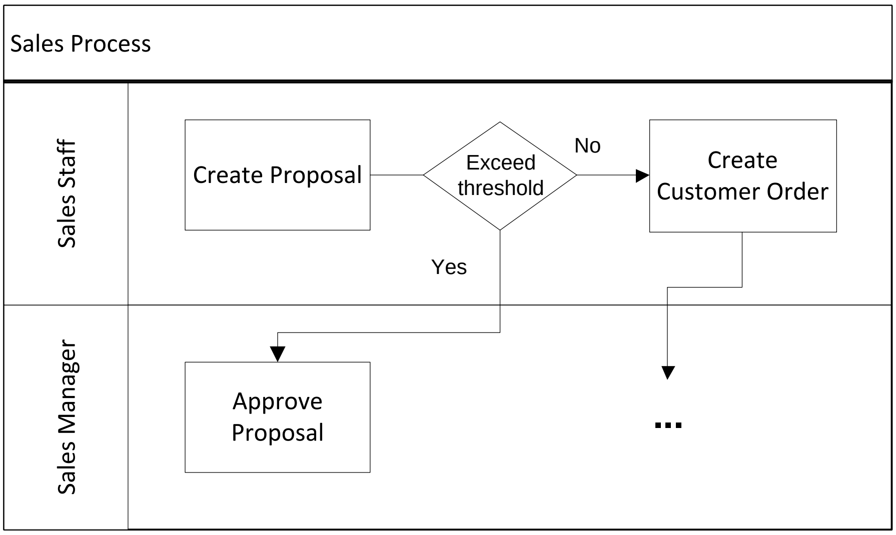

Figure 18. Scenario 2: Shortening the approval process

Therefore, in the second scenario, we analyze the impact of removing the approval activity by the sales manager, if the value of the proposal does not exceed the approval limit. In other words, when the value of the proposal remains below the defined threshold, the employee who is assigned to perform the process step is also authorized to make the decision. After changing, the approval activity is partly removed from the sales process.

As the SD simulation results show, the process benefits from several improvements, such as fewer delays, lower overhead costs and increased employee morale that in turn positively influences the empowerment for the task. Table 9 summarizes the SD simulation results.

Policy parameter	Base scenario	Shortening the approval process
Work completion	1,300 tasks (6.5 tasks/employee)	1,573 tasks (7.87 tasks/employee)
Process duration	7 months	5.5 months
Number of employees	200 employee	200 employee
Training overhead	5%	5%
Employee morale	68%	82%

Table 9. SD simulation results from scenario 2

We can conclude that the partial elimination of the approval activity by the sales manager decreases the process duration by 1.5 month (approx. 21% improvement). This results in an increase in employee morale to 82%. Compared to the base scenario, we can summarize that partly removing this controlling activity leads to an overall improvement of approx. 20% in employee morale.

2.5 Discussion

Pertaining to the research questions we set out with, we propose the following findings.

(1) Which impact factors and relationships have to be considered for a SD simulation model for BPC projects?

Employing the concept of a SD approach for developing a simulation model put forth by Baguma and Ssewanyana (2008), we coded 65 case studies departing from the central (dependent) variable employee morale. We identified 18 relevant factors impacting our dependent variable in a direct or indirect manner. 27 relationships among these factors or between factors and the dependent variable were elicited through the coding process. We found the factors of productivity, IT resources and measurement for controlling and monitoring business processes to have the largest impact on employee morale. Employee morale in turn positively influences performance measurement, productivity and, maybe most importantly, customer satisfaction. We identified several feedback loops. The resulting SD simulation model represents a playing field for devising concrete guidance for practitioners within BPC project environments. In order to exemplify this process, we devised two heuristics and presented quantitative analyses for the resulting scenarios, demonstrating the concrete applicability of the identified impact factors and relationships to the goal of actively shaping a BPC project environment.

(2) What are the benefits and limitations of SD for BPC learning offerings?

We have shown that SD is capable of creating easily graspable and remarkably detailed models of influence factors and interactions within BPC projects. Employing SD for deriving learning environments allows researchers and practitioners to foot their analyses on vast amounts of real-world data. This also allows for the quantification of implicit and tacit impacts and relationships. The resulting model consists of clearly defined elements, including dependent and independent variables as well as directed and weighted relationships among these variables. Especially when visualized by means of a causal loop model, this makes for a strikingly intuitive and comprehensible representation of BPC project environments. If the learning process is supported by software capable of simulating these models, studying the relationships between factors can even take on a game-like character with learners being able to run through a variety of scenarios while internalizing the presented factors and feedback loops (Baume, 2009). Moreover, coupled with the quantitative nature of these models, such software may transcend ordinary learning purposes by enabling decision-makers to run concrete SD simulations of different variable configurations, each representing a certain set of managerial policies.

Despite these tremendous capabilities, employing SD for devising BPC learning offerings brings forth some difficulties. Firstly, the coding of the vast amounts of real-world experiences is time and resource consuming and requires skilled personnel. Even though the goal is to mitigate subjective influences, the identification of impact factors and the elicitation and evaluation of relationships is bound to be subject to a certain degree of personal interpretation during the coding process. Further, in order to arrive at a usable model, information has to be aggregated and details omitted during the process, which results in a simplified representation of reality. Similarly, any quantification of relationships enabled by the resulting SD simulation models may naturally only be approximations of a real project environment.

We contribute to the domain of BPC by making the abundance of case studies on BPC projects available to SD modeling. We have shown that SD is an appropriate methodology for reviewing and consolidating the complex and often non-linear findings from BPC case studies for learning purposes. By suggesting SD as an effective instrument to illustrate, explain and convey the complex relationships between important variables in BPC projects, we contribute to the domains of knowledge management and learning. When controlled manipulation of the actual system (i.e. project environment) itself is unfeasible due to time, cost, moral or other considerations, the proposed approach can serve as a framework for assessing the implications of different managerial policies and procedures. The current lack of BPC SD simulation models in both literature and practice should make for a fertile ground in the BPC community with many practitioners eager to obtain non-committal means of experimentation, testing and scenario planning.

In addition to laying the groundwork for an empirically supported system dynamics approach in BPC, this paper extends the theory of BPC by identifying factors impacting employee morale in BPC projects as well as identifying relationships among these factors. This is a useful beginning in helping practitioners obtain a better understanding of managing employee morale in BPC projects. We expect potential future use of such modeling techniques for learning and simulation purposes to have a positive impact on BPC success rates in general.

Our findings establish various needs and possibilities regarding future research. While we found the dependent variable employee morale to be of crucial importance to the success of BPC projects, the complex nature of the considered environments calls for an extension of the model by accounting for further dependent variables. The feasibility of these models should be tested in learning environments comprised of practitioners and students. Feedback pertaining to the understandability, comprehensiveness and intuitiveness of the resulting learning tools may be used to improve both the models themselves and the software simulations making the models accessible to the learner. Further, the model should be tested in research for formulating and testing different hypotheses as well as in practice as a group decision-making tool for managers.

2.6 Conclusion

The focus of this research was to explore the usefulness of SD for consolidating the findings from case studies and conveying the structure and dynamics of BPC projects. As a means of demonstration and exploration, we developed a SD simulation model for effectively managing and understanding employee morale in BPC projects. The model was designed on the basis of empirical information gathered through a set of 65 case studies. Incorporating data from real-world applications, we elicited impact factors and their relationships among each other. The resulting model strives to comprehensively capture dynamic characteristics and nonlinearities of BPC projects with an emphasis on the management of employee morale. Maybe most importantly, the employed approach cogently demonstrates the benefits of SD as a way to review and consolidate the abundance of BPC case studies.

Our findings can help to facilitate learning processes in BPC project environments and lay the groundwork for SD model simulations allowing practitioners to analyze different scenarios with minimized resources and free of risk. Future research may build on this in order to craft learning environments and powerful simulation applications, which enable organizations to efficiently allocate their resources in the course of BPC projects, subsequently reducing failure rates and maximizing benefits.

3 Emergent Risk in Business Process Change Projects[6]

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Status	Accepted

Table 10. Fact sheet publication P3

Abstract: Purpose – Even today still many BPC initiatives fail and cause high overruns for organizations undergoing BPC initiatives. It is therefore important that BPC practitioners and researchers understand the risks inherent in BPC projects and that they adapt their risk management processes to account for and mitigate these risks. Thus, this study investigates which emergent risks matter in BPC project.

Design/methodology/approach – We adopted case survey methodology and investigated data from 130 case studies to show the nature and magnitude of relationships between organizational support risks, volatility risks and BPC project and process performance.

Findings – Our results show that organizational support risks influence both the overall BPC project performance and process performance. Whereas, volatility risks influence project performance but appear to have no direct impact on the process performance. Both organizational support risks and volatility risks show influence on project management practices.

Research limitations – Our study show several limitations that might be assigned to the case survey methodology, such as use of secondary data or publication bias.

[6] Originally published as: Jurisch, Marlen; Rosenberg, Zuzana; Krcmar, Helmut: Emergent Risks in Business Process Change Projects. Business Process Management Journal, 22(4), 2016

Practical implications – We provide considerable support which emergent risks matter in BPC projects.

Originality/value – The contribution of this study takes several forms. It fills a gap in the literature concerning emergent risk factors inherent in BPC projects. We provided theoretical explanation of the effects of emergent risks on BPC project and process performance. And lastly, we have demonstrated the usefulness of case survey methodology in BPC research.

3.1 Introduction

Despite the considerable experience gained over the last two decades, managing risks induced by improving business processes is still an on-going challenge for business process change (BPC) practitioners and researchers alike (Trkman, 2010; Cao et al., 2001; Strebel, 1996; Kliem, 2000). An example of BPC failure due to the imposed risk of client change was the initiation of implementing an ERP system by FoxMeyer Drug Company striven for a competitive advantage. FoxMeyer invested in their change project $65 Million expecting a save of $40-$50 Million annually, as well as to gain competitive advantage (Jesitus, 1997). However, after its major client, Phar-Mor went bankrupt FoxMeyer signed a major new client contract, which required major changes to the projects. After the costs run over $100 million the project was declared as failure and within some time FoxMeyer went bankrupt (Jesitus, 1997). The literature provides many other examples of business process change failures due to imposed risks and concludes that most companies have no longer the luxury of funding BPC projects that are not showing the expected performance (e.g., Hammer & Champy, 1993; Al-Mashari et al., 2001; Trkman, 2010). Delivering the expected performance from BPC initiatives thus remains a critical challenge for many organizations (Hill & McCoy, 2011).

Gemino et al. (2008) propose that project performance can be better understood by separating risks into two different categories. They suggest separating risks into earlier (a priori) risk factors, which might be estimated before a project begins, such as budget, duration, or inexperience of the team and later (emergent) risk factors, which evolve during the course of a project, such as client manager or executive sponsor change. By investigating the risks of an organizational change, Kanter et al. (1992) found two kinds of risks factors: external and/or internal, such as functional, financial or general project risk factors. They conclude that these kinds of risk factors result in different degrees of changes, which influence the whole success of change initiative.

Several BPC researchers have focused on a priori risks or critical factors influencing BPC success (e.g., Scott & Vessey, 2002; Trkman, 2010; Holland and Light, 1999; Motwani et al., 2005; Jurisch et al., 2012), whereas others have focused on design and process of risk management (Kliem, 2000). However, emergent risks and their link to BPC performance remained rather unexplored (Trkman, 2010; Jurisch et al., 2012). Moreover, improving our understanding of various emergent risks imposed in BPC projects are key to understanding how to conduct future BPC projects successfully (Olsson, 2007; Sarker et al., 2006). Adding to the complexity of such projects, the success of BPC projects should not only be measured by the actual project performance but also by the performance of the changed business process (Jurisch et al., 2014). Against this background, we aim to answer the following research question:

Which emergent risks influence the performance of IT-enabled BPC projects and/or the performance of the changed business process?

To investigate how emergent risks affect the project and process performance of BPC initiatives, we employ a model of IT project performance proposed by Gemino et al. (2008) as our research model. We further adopted case survey methodology to investigate our research question, since it presents a powerful approach for identifying and statistically testing patterns across case studies (Larsson, 1993; Lucas, 1974). More so, case survey methodology draws on the richness of numerous case studies, which allows for wider generalization.

The paper is organized as follows. In section 3.2, we describe our research model and propose our hypotheses. Section 3.3 describes the case survey methodology, including the literature search, coding of case studies and data analysis. Section 3.4 presents the results and section 3.5 discusses those results, their implications and limitations. We conclude the paper in section 3.6.

3.2 Theoretical Background and Hypotheses Development

In the following section we describe our research model of emergent risk and the corresponding hypotheses.

3.2.1 Research Model of Emergent Risks

Gemino et al. (2008) propose a temporal model of IT project performance, which can be used to suggest a different categorization of IT project risk factors. They classify risks into risks factors that are present when a project is defined (a priori) and risk factors that either emerge or are revealed as the project is executed (emergent) (Gemino et al., 2008). In general, they suggest that risks factors such as budget, duration, technical complexity, or inexperience of the team can be estimated at the beginning of the project and therefore refer to them as a priori risk factors. Emergent risk factors refer to the new risks that emerge during the course of a project and to the actions of project managers to deal with the risk and progress of the project (Gemino et al., 2008). They identified two categories of emergent risks: a) organizational support risks and b) project volatility risks. Organizational support risks involve executive sponsor support and user support (Gemino et al., 2008). Depending on the circumstances, organizational support can be seen both as a risk (e.g., lack of management support) or as an important resource for project managers (e.g., high management support). For the purposes of our case survey, organizational support risks present "an aggregate measure of the lack of support that the project and the project manager […] were given by the base organization" (Gemino et al., 2008). The second category of emergent risks includes volatilities in project targets (e.g., budget, schedule, etc.), key personnel and external conditions (Sharma & Yetton, 2007; Gemino et al., 2008). While such volatilities can have a strong impact on the performance of a BPC project, they are also frequently outside the direct influence of the project team. Given that BPC projects may plausibly fail as a result of problems concerning any one or any combination of these two emergent risk categories, we included both of them in the model to account better for variance in performance and to investigate their relative importance (see Figure 19). Since, we are interested on the direct effect of emergent risks on the BPC project and process performance, we excluded a priori risk factors from our research model.

3.2.2 Hypotheses Development

User participation

Following Gemino et al. (2008) we define user participation as three item construct: to what extent user could make changes in the project management process, the degree users were informed about the progress and problems and the possibility to evaluate the work of the project management team. A number of BPC authors highlight the importance of user participation and empowerment in BPC project initiatives (e.g., Leverment et al., 1998; Al-Mashari & Zairi, 2000; Newman et al., 1998). For example a major UK health service provider notices that user participation is one of the most important factors for BPC project success (Leverment et al., 1998). Providing appropriate information about the progress and status of the change project should be an essential part of the employee communication. Al-Mashari & Zairi (2000) found in the case of the SAP implementation at Manco there was almost no formal communication strategy and no possibility for the users to evaluate and get involved. This means virtually no user participation was given, which is one reason why the implementation was considered as failure. Newman et al. (1998) considered the change project at a large UK bank as success because of the active user participation and excellent training provided for the employees. Hence, a lack of user participation can result in failure of BPC project. Thus, we hypothesize:

H1: The higher the user participation the higher the BPC project performance.

User involvement is not only a major facilitator of the overall project success, but particularly important for the enhancement of the business process performance (Newman et al., 1998; Lee & Chuah, 2001; Proctor & Gray, 2006; Paper et al., 2001; Kemppainen, 2004). Empowering the users during a change program creates awareness for the value-creating core processes and thus helps to enhance the process quality (Newman et al., 1998). A major industrial manufacturer in Hongkong notices that “worker’s perception and understanding about their job” is essential for the quality of the products and services provided (Lee & Chuah, 2001). User participation is also crucial for customer understanding to enhance the customer satisfaction (Newman et al., 1998; Proctor & Gray, 2006). During a large change project at Honeywell a new training philosophy was started with the result of educating employees about customer satisfaction and its importance for the value-creation (Paper et al., 2001). Thus, we expect:

H2: The higher the user participation the higher the business process performance.

Harvey (1994) highlighted the importance of user participation as an important factor influencing project management practices. He reported an example from Lucas Industries, who conducted a large change project to get profitable again. The results were an agreement on the resources needed for the project, a detailed project plan and an agreement on the communication plan for the change project, which would not have been created without high user participation involvement (Harvey, 1994).

Hence, a lack of user participation can result in a weak project management practices. Thus, we expect:

H3: The higher the user participation the better the project management practices.

Top management support

Top management support in BPC projects means that the decision to change was supported by the top management of the respective organization at the project beginning, so the project was planned from the beginning on with the top management's involvement (Teng et al., 1998). The necessity of top management in BPC projects was first mentioned by Hammer and Champy's (1993) work, who propose a steering committee of senior managers to initiate and lead the change project. The senior management of Contributions Agency had a lack of commitment to the project goals which caused that the organization failed to achieve all project goals (Harrington et al., 1998). In contrast, Reuters started a major change project to create an effective customer service company. According to the CEO, top management support was vital for the whole project to transform the company (Harvey, 1994). The Western Provident Association believed that change must be driven top-down and noticed that top management sponsorship "ensured that the major changes in the organization were pushed through at each stage of the project" (Harvey, 1994). Similar experiences were established at CIGNA Corporation (Caron et al., 1994) and Mobil Oil Australia, where the visible top management commitment was seen as key to the achievement of the radical changes (Martin and Cheung, 2002). Considering the high variance in the project performance between a lack of support and high top management support, we hypothesize:

H4: The higher the top management support the higher the BPC project performance.

Top management of American Express initiated a quality leadership program which helped them to increase efficiency, enhance effectiveness and reduce the cost base (Ballou, 1995). According to Neely et al. (1995) business process performance can be measured through criteria such as efficiency and effectiveness. Another example of the change program at IBM in the early 1990s allowed them to achieve high improvements regarding the efficiency of the business processes, particularly in their cost structure (Weiler, 1995). A number of authors consider top management as essential success factor in achieving improvements in efficiency and effectiveness (Al-Mashari & Zairi, 1999; Dale, 1994; Weiler, 1995). Therefore, we hypothesize:

H5: The higher the top management support the higher the business process performance.

The linkage between top management support and project management practices has been discussed in BPC literature (e.g., Harvey, 1994; McAdam & Corrigan, 2001). If top management fails to provide the project management with the necessary empowerment, the project will not produce the anticipated results and project managers would not employ and use the appropriate methods and tools (Harvey, 1994). Thus, we hypothesize:

H6: The higher the top management support the better the project management practices.

Governance Volatility

Governance volatility refers to the number of changes of the project manager, client manager and executive sponsor during the project (Gemino et al., 2008). A number of BPC authors (Newman et al., 1998; Shin & Jemella, 2002; Hammer & Champy, 1993; Harvey, 1994) reported in their research that BPC initiatives with continuity in the project management, client management and executive sponsorship personnel were smoothly accomplished and celebrated as success. Huq & Martin (2006) observed in a large U.S. hospital a replacement of top and second level management due to a pending merger (Huq & Martin, 2006). After the completion of the merger the interims management left the company and new appointed management continued the ongoing BPC project with less expertise so that the final result was just a moderate success (Huq & Martin, 2006). Hence, if there is high volatility in governance, the BPC project will likely not meet its performance goals. Thus, we hypothesize:

H7: The lower the governance volatility the higher the BPC project performance.

Many BPC authors (e.g., Newman et al., 1998; Shin & Jemella, 2002; Hammer & Champy, 1993; Harvey, 1994) reported that BPC projects with low governance volatility achieve cost savings, increase productivity or improve the customer satisfaction. Other researchers (e.g., Huq & Martin, 2006; Kemppainen, 2004; Sarker & Lee, 2000) reported that the change of executive sponsors, project managers, or client managers is often connected with a delay in the schedule, increase of costs, or decrease of productivity. Regarding the change of the executive board in the implementation of an ERP system, governance volatility was both delaying the schedule and of high cost (Kemppainen, 2004). Similarly, Huq & Martin (2006) reported a delay in the schedule as consequence of high governance volatility. Therefore, we expect:

H8: The lower the governance volatility the higher the business process performance.

Kemppainen (2004) reported results from implementing a new ERP system in a global operating organization, where the initially sponsoring top management moved away from the project when the first problems regarding the high complexity of the change project were discovered. As a consequence, new board of executives including CEO was announced (Kemppainen, 2004). The new executive sponsors first initiate the change of the project management practices, especially the implementation plan and the project management tools and methods applied which took some time to get accepted (Kemppainen, 2004). Thus, the identified relation between governance volatility and project management practices leads to the following hypothesis:

H9: The lower the governance volatility the better the project management practices.

External volatility risks

External volatility is defined as a change in external factors, which are affecting the project (Gemino et al., 2008). According to Gemino et al. (2008) these factors refer to the changes in the competitive environment, business strategy, supplier/vendor relationship, or a regulatory or governmental change. Several BPC researchers (e.g., Newman et al., 1998; Shin & Jemella, 2002; Anderson & Woolley, 2004) reported that BPC projects with a consistent business strategy, well-defined supplier or vendor relationships and no or only few regulatory changes could successfully reach the planned improvements. Anderson & Woolley (2004) analyzed the reorganization and efficiency program of the suppliers of Unilever and measured improved product and service quality with a positive effect on customer satisfaction due to the reduction of external volatility. Hence, if there are only minor volatilities in external risks, the BPC project will likely meet its performance goals. Thus, we hypothesize:

H10: The lower the external volatility the higher the BPC project performance.

A number of authors (Currie & Willcocks, 1996; Kock & McQueen, 1996; Stemberger et al., 2007; Palmberg, 2010) showed the difficulty of reaching improvements at the business process level in case of a high external volatility such as competition, regulation, strategy, or relationships. Declining results and pressure to improve profitability as new business strategy made it difficult to create employee commitment for the BPC project in a large logistic company (Palmberg, 2010). The result was a reduction in employee morale and satisfaction and service quality (Palmberg, 2010). Knock Jr. and McQueen (1996) and Currie and Willcocks (1996) reported that some companies facing additional environmental changes during their BPC projects are forced to reduce the initial planned process improvement goals. Due to the increasing competition from insurance companies, Royal Bank only had the opportunity to increase profit by job reduction (Currie & Willcocks, 1996). Hence, high external volatility can impede the achievement of BPC goals. We therefore hypothesize:

H11: The lower the external volatility the higher the business process performance.

Organizations with high pressure coming from external factors have serious problems in establishing a continuous and consistent project management philosophy, as the BPC projects have to face and incorporate new changes (Currie & Willcocks, 1996; Kock & McQueen, 1996). For example, a large public sector organization in Brazil operating in construction industry changed its strategy due to the competitive pressure and established new project management tools to achieve the new goals (Currie & Willcocks, 1996; Kock & McQueen, 1996). However, due to the short development schedule, these new project management tools lacked the appropriate scope and functionality to generate sustainable results (Currie & Willcocks, 1996; Kock & McQueen, 1996). Hence, the identified relation between external volatility and project management practices leads to the following hypothesis:

H12: The lower the external volatility the better the project management practices.

Target volatility risks

Target volatility, in contrast to external volatility measures the changes in internal factors affecting the project (Gemino et al., 2008). These internal factors are the number of project schedule changes, budget changes, or project scope changes (Gemino et al., 2008). A number of BPC authors (Jackson, 1995; Huq & Martin, 2006; Al-Mashari & Zairi, 2000; Brown & Riley, 2000; Kemppainen, 2004) show the negative effect of high target volatility in terms of changes in schedule, budget, or scope on the overall project performance. Huq and Martin (2006) reported a delay in the project schedule of 6 months that caused the BPC benefits being not apparent for several years. Another example of TELECO (a pseudonym for a large U.S. telecommunication company) showed that the BPC project was changed in scope and ultimately the CEO in favor of the project retired and was replaced by a new executive with the opposite opinion about it (Sarker & Lee, 2008). Finally, the new CEO stopped the project and declared it as failure since the anticipated targets could not be reached (Sarker & Lee, 2008). Therefore, we hypothesize:

H13: The lower the target volatility the higher the BPC project performance.

Several BPC authors (Newman et al., 1998; Shin & Jemella, 2002; Hammer & Champy, 1993; Harvey, 1994) reported that BPC projects with low target volatility could achieve dramatic improvements in productivity, cost savings and customer and employee satisfaction. High target volatility typically affects the business process performance of an organization (Huq & Martin, 2006; Jackson, 1995; Al-Mashari & Zairi, 2000). Exceeding the project budget increases the costs of a BPC project and can even result in a loss (Huq & Martin, 2006; Al-Mashari & Zairi, 2000). For example, Manco Group could not achieve many improvements due to the exceeding costs in the investment of $2.8 million for their BPC project (Al-Mashari & Zairi, 2000). Thus, we expect:

H14: The lower the target volatility the higher the business process performance.

Huq and Martin (2006) reported from a BPC project of a large U.S. hospital, 14 gaps identified by the implementation team, which caused a delay of six months of the go-live date. Since new processes had to be developed, this change in schedule caused to update the project plan, adapt the project management practices for the new configuration of the software, testing and documentation (Huq & Martin, 2006). Hence, the identified relation between external volatility and project management practices leads to the following hypothesis:

H15: The lower the target volatility the better the project management practices.

Project management practices

Previous research also suggests that the impact of these emergent risks can be managed and mitigated through project management practices (Barki et al., 2001; Nidumolu, 1995; Wallace et al., 2004; Gemino et al., 2008). Project managers can take an active part throughout the course of a BPC project in counteracting these risks. Thus, emergent risks and project management practices are expected to be related to each other but also to influence project and process performance (Kettinger & Grover, 1995; Gemino et al., 2008; Wallace et al., 2004). Therefore, we hypothesize:

H16. The better the project management practices the higher the BPC project performance.

H17. The better the project management practices the higher the business process performance.

Lastly, previous research disclosed that in BPC projects the project performance strongly influences the performance of the changed business process (Jurisch et al., 2014). Thus, we hypothesize:

H18. The higher the BPC project performance, the higher the business process performance.

Figure 19 summarizes our research model with the corresponding hypotheses.

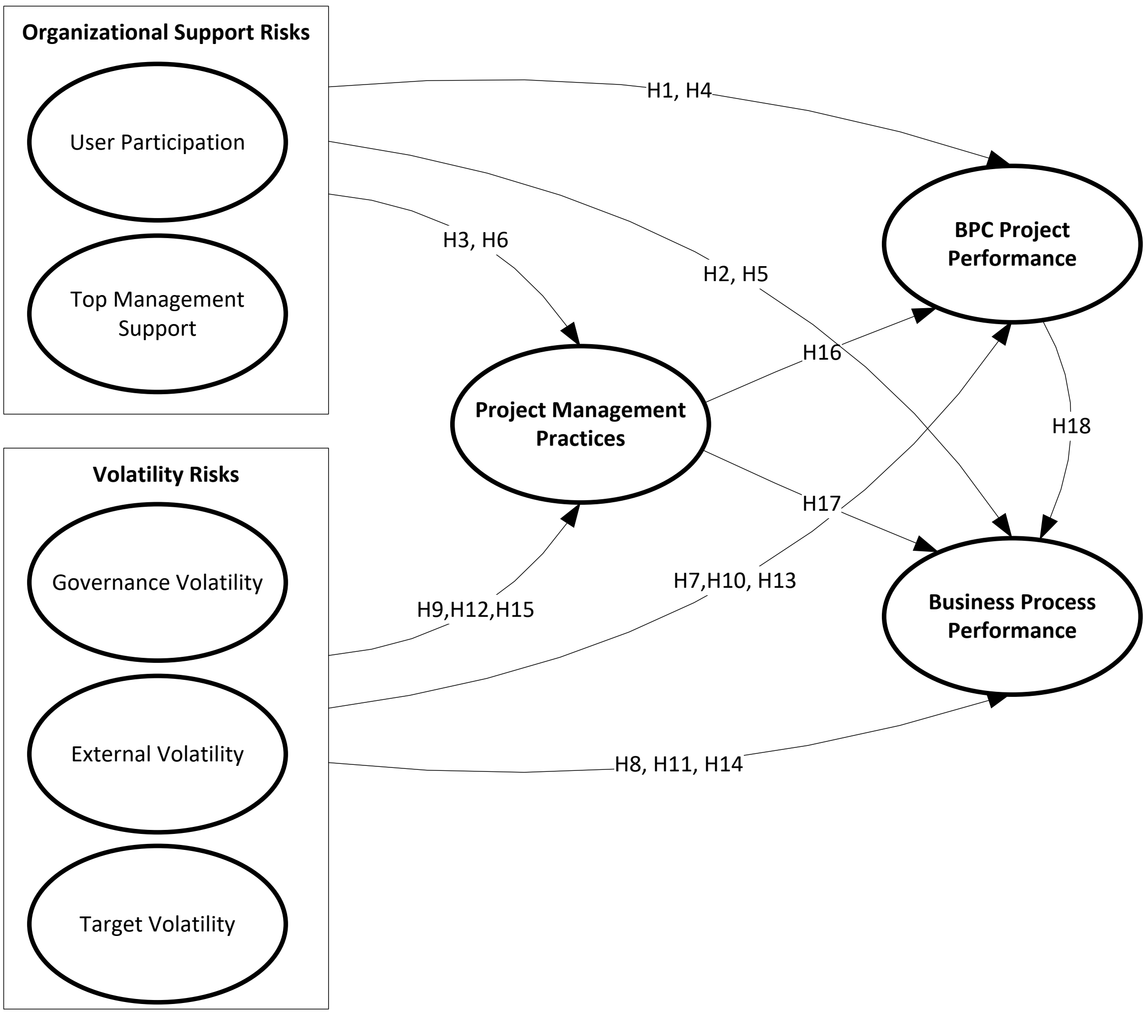

Figure 19. Research model and corresponding hypotheses

3.3 Research Method

We investigated these hypotheses using case survey methodology, which is a suite of quantitative techniques to synthesize research findings across multiple case studies (Glass, 1976; Hunter & Schmidt, 2004; King & He, 2005). Case survey methodology, also known as meta case analysis or content analysis is a widely accepted methodology in related research domains such as management, IT outsourcing, or recently in IS research (Jurisch et al., 2013). According to several authors (Glass et al., 1981; Hunter & Schmidt, 2004; Rosenthal & DiMatteo, 2001) case survey methodology enable researchers to estimate more reliable effect sizes than traditional review procedures, such as narrative or descriptive reviews. Furthermore, the results from case survey methodology are often treated as reliable, replicable and therefore suitable for theory development and hypotheses testing (Bullock & Tubbs, 1990; Rosenthal & DiMatteo, 2001). The choice of case survey methodology for our research satisfies four criteria proposed by Larsson (1993). First, the research domain produces a vast number of case studies (Yin & Heald, 1975), in our case BPC research field provides a large number of case studies reporting successes and failures of BPC initiatives. Second, this method is helpful if the unit of analysis is the organization (Larsson, 1993); i.e. the organization performing the BPC project. Third, if a number of impact factors is of interest (Jauch et al., 1980). Fourth, if it is difficult to obtain primary data in the research domain. Following the recommendation by Larsson (1993), the process of our case survey analysis was performed in three major steps: (1) literature search, (2) coding and (3) analysis.

3.3.1 Literature Search

Our sample consists of case studies reported in journals, conference proceedings, dissertations, working papers, book sections and magazine articles. We included conference proceedings, dissertations, working papers and magazine articles in our literature search to address the "file-drawer problem". The file-drawer problem refers to the observation that results of published studies may report overestimate effect sizes compared to unpublished studies (Rosenthal, 1979).

First, we conducted a systematic keyword search including key words "business process reengineering", "business process transformation", "business process innovation", "continuous process improvement", "six sigma" and variants with the keyword "case study". We searched databases such as Emerald, EBSCO, ScienceDirect, JSTOR, ACM Digital Library. These databases included the major journals and conference proceedings in the business process management area, such as Business Process Management Journal, Business Change and Reengineering, International Journal of Operations & Production Management, or Journal of Management Information Systems. Dissertations and Theses were found in the databases such as ProQuest and WorldCat. Book sections were found through traditional channels; i.e. libraries. Second, following recommendations by Webster and Watson (2002), we performed forward and backward searches. Working papers were found by screening the websites of key authors identified by forward and backward search and conducting keyword searches in Google Scholar. In a third step, we explored titles, abstracts and keywords. We further included a study in the case survey analysis if it satisfies three criteria. First, the study investigates project and process performance. Second, the study reports information on the emergent risks. Third, the study provided a rich description of the events.

The resultant case survey analysis sample included 130 case studies published between 1992 and 2013. The resultant distribution across publication type was as follows: journals (86), conference proceedings (16), dissertations (4), book sections (22), magazine article (1) and working paper (1). Of these cases 93 were in private and 37 in public organizations. The cases varied in terms of sectors (e.g., finance, health, education and manufacturing) and types of BPC projects (e.g., business process reengineering, business process transformation, business process innovation, continuous process improvement and six sigma).

3.3.2 Coding

Our coding scheme consisted of variables representing aspects of the study design and several control variables (e.g., research designs, publication outlet and time frames of the case studies). We relied on multi-item scales (at least two items) for each latent variable and five-point Likert scales to code each variable. This is consistent with theoretical reasoning of Srnka and Koeszegi (2007), who state that the coding of the case studies refers to the systematic assignment of codes (numbers) to units based on the coding scheme Besides the eight variables discussed in this paper (e.g., emergent risks, project management practices, project and process performance, etc.), our coding scheme included several additional variables. In total, our coding scheme comprised 44 variables and 137 items. This broader coding scheme allowed us to not only collect information on the variables analyzed within this article (e.g., risks, project performance, process performance, etc.), but also to gather information of other factors influencing BPC project success. More so, the broader coding scheme permitted us to spread some of the risks involved in case survey research.

The coding procedure was performed in three steps. In the first steps, two experienced raters coded several pilot cases studies with the list of codes to become familiar with the coding scheme. Afterwards, they met personally and compared their coding results for calibration purposes. In the second step, the raters independently coded each case study. In the second, we established weekly meetings and discussed any discrepancies until we had reached a consensus. According to Bullock and Tubbs (1990) this procedure helps to eliminate individual disparities. Resolving discrepancies in this way is said to be a "superior way to correct coding mistakes" (Larsson, 1993). In the third step, after both raters completed the coding, we established inter-coder reliability using Krippendorf's (1980) Alpha. At the outset the results of Krippendorf's Alpha was 0.77, which indicates a substantial agreement between the raters.

3.3.3 Analysis

The hypotheses are tested using the partial least squares (PLS) procedure. PLS is suitable to analyze the data due to the following criteria proposed by Chin and Newsted (1998) and (Chin, 1998): (1) the hypotheses are grounded in specified impact factors; (2) handles both formative and reflective epistemic relationships between the latent variables and its measures; (3) avoids the problems with small sample size. (Diamantopoulos, 2006) argue that PLS provides more accurate estimates of the paths among constructs, which are usually biased by measurement error when using techniques such as multiple regressions (Diamantopoulos, 2006). Furthermore, PLS procedure uses component-based estimation and facilitates the exploration of two models of a structural equation model, the measurement (outer) model, examining the relations of measurement variables and their latent variables and the structural (inner) model examining the latent variables to each other (Diamantopoulos, 2006).

To ensure validity and reliability of our results, we followed the recommendations by Hair et al. (1998) and assessed the quality of the measurement model and structural model. This assessment analysis was performed in two stages. We employed SPSS and SmartPLS 2.0 M3 to assess the measurement and the structural model.

In the first stage, we assessed the quality of the measurement model including reflective and formative indicators. We proved the four widely used and well defined assessment criteria for the measurement models with reflective constructs: content validity, indicator reliability, composite reliability and discriminant validity (Chin, 1998). These assessment criteria were verified by adopting explorative factor analysis (Krafft et al., 2005). For the measurement models with formative constructs, we applied three assessment criteria: indicator relevance, multicollinearity and nomological validity (Chin, 1998).

If successful and the latent constructs prove valid and reliable, stage two necessitates the assessment of the structural model. We employed three criteria recommended in PLS literature; i.e. the R^2values, the effect size f^2 and the extent of significance and β-coefficients, to assess the explanatory and predictive power of the structural model. The central criterion for evaluating the structural model is the level of explained variance R2 of the dependent constructs. R^2-values of 0.67, 0.33 and 0.19 for endogenous latent variables are substantial, moderate, or weak respectively (Chin, 1998). To estimate the extent of β-coefficients, we used the PLS path algorithm procedure. For the significance of the path coefficients, we performed the bootstrapping re-sampling technique with 2000 resamples (Efron & Tibshirani, 1993). The effect size f2 investigates the substantive impact of each independent variable on the dependent variable (Cohen, 1988). Values of 0.02, 0.15 and 0.35 indicate a small, medium, or large impact, respectively (Chin, 1998). The effect size f^2 for the structural model was estimated by re-running several PLS estimations, excluding in each run one of the explaining latent constructs.

3.4 Results

The following section provides (1) the results of the measurement model and (2) the results of the structural model.

3.4.1 Measurement Model

The assessment criterion content validity was verified by adopting explorative factor analysis (Krafft et al., 2005). We used direct oblimin rotations to identify the loadings and the variance. Our results show a successful verification of the content validity, since the accumulated explained variance yielded 65.75% and the indicators of each construct charge on one factor.

By assessing the indicator reliability, the latent variable variance should explain at least 50% of the indicator and the factor loadings of latent manifest variables should be above 0.70 (Carmines & Zeller, 1979). Hulland (1999) furthermore suggests to eliminate indicators with factor loadings below 0.4. Our results show that the factor loadings were mostly beyond the acceptable value of 0.70 with the exception of five indicators (see Table 11). We did not eliminate any indicators, as none of them was below the limit of 0.4.

According to Fornell and Larcker (1981) the composite reliability estimates the internal consistency of the indicators measuring a particular factor. The value of the internal consistency should be at least 0.60 (Bagozzi and Yi, 1988). Our results show support for the composite reliability, as the internal consistency of the six reflective constructs was at least 0.60 (see Table 11).

The last assessment criterion discriminant validity refers to the appropriate patterns of inter-indicators of a construct and other constructs (Gefen et al., 2000). The results of the average variance extracted (AVE) value is for all constructs beyond the recommended level of 0.50 (Fornell & Larcker, 1981). We further, determine the square root of the AVE values for each construct, which is seen as crucial value that should be higher than the correlations between it and all other constructs (Fornell & Larcker, 1981). Our data analysis disclosed that the squared roots were higher for all constructs thus successfully verifying discriminant validity.

Table 11 summarizes the results of the assessment of the quality of our measurement model and exhibits the factor loading, the AVE and the composite reliability.

Construct	Items	Sources adapted from	Loadings	AVE	Composite reliability
User Participation (Org. Support Risk)	The employees were satisfied with the quality of the information provided on the change.	(Kotter, 1996)	0.939	0. 960	0.979
	The employees understood how the change would affect them.	(Huizing et al., 1997; Markus and Grover, 2008)	0.926		
Top Management Support (Org. Support Risk)	Top management ensured the availability of adequate resources throughout the change project.	(Grover, 1999; Grover and Kettinger, 1995)	0.944	0. 798	0.888
	Top management commitment was still high at the end of the change project.	(Grover, 1999; Grover and Kettinger, 1995)	0.632		
Governance Volatility (Volatility Risk)	The project manager changed during the course of the change project.	(Gemino et al., 2008)	0.936	0. 901	0.948
	The executive sponsor (top management) changed during the course of the change project.	(Gemino et al., 2008)	0.728		
External Volatility (Volatility Risk)	There was a change in the competitive environment that affected the project	(Gemino et al., 2008)	0.612	0. 745	0.897
	There was a change in the business strategy that affected the project.	(Gemino et al., 2008)	0.734		
	There was a change in the supplier/vendor that affected the project.	(Gemino et al., 2008)	0.814		
Target Volatility (Volatility Risk)	The project schedule changed during the course of the change project.	(Gemino et al., 2008)	0.838	0.811	0.928
	The project budget changed during the course of the change project.	(Gemino et al., 2008)	0.682		

	The project scope changed during the course of the change project.	(Gemino et al., 2008)	0.709		
Project Management Practices	The PM team managed project risks and implements proper measures to address them.	(Crawford, 2005)	0.579	0. 642	0.843
	The PM team managed the needs, expectations, priorities and interests of project stakeholders.	(Grover, 1999)	0.506		
	The PM team applied PM methods, tools and techniques to plan and manage the change project (e.g., project plan, frequent team meetings, etc.).	(Gemino et al., 2008)	0.786		

Table 11. Factor loadings, AVE and composite reliability

The first assessment criterion for the measurement models with formative constructs represents indicator relevance that determines which indicators contribute most substantially to the construct (Sambamurthy & Chin, 1994). In order to demine the indicator relevance, we compare each indicator's weight. We did not eliminate any indicator, as according to Bollen and Lennox (1991) in reflective measurement models, the factor loadings can be less than 0.40. To verify multicollinearity, which indicates the indicator's degree of linear dependency, we examined both the indicator's correlation matrix and the variance inflation factors (VIF). The correlation coefficients were partially high (i.e., the highest correlation coefficient was 0.845). However, multicollinearity did not actually bias the results as all VIF were below the recommended level of 10 (Eckey et al., 2001). The nomological validity and relevance of indicators (Sambamurthy & Chin, 1994) were also verified using PLS software. We performed bootstrapping with 6000 resamples for testing the statistical significance of path coefficients using t-tests.

In summary, the statistical analysis showed empirical support for the reliability and validity of the scales of the measurement models.

3.4.2 Structural Model

The results of the evaluation of the structural model are presented in Table 12. The results of $R^2$of our structural values represent moderate values with 0.477 (project performance), 0.423 (process performance) and 0.332 (project management practices). The results of the effect sizes f^2 show a small, medium and large impact of the independent variables on the dependent variables (ranging from -0.310 till 0.530) (see Table 12). Thus, our results show support for hypotheses H1, H3, H4-H7, H13 and H15-H18. Hypotheses H2, H8-H12 and H14 were not supported in our study.

Correlation	**β**	**t-value**	**Significance**	**f²**
H1: User participation → BPC project performance	0.053	2.813	**	0.110
H2: User participation → Business process performance	0.011	0.285	n.s.	- 0.006
H3: User participation → Project management practices	0.310	13.544	***	0.310
H4: Top management support → BPC project performance	0.501	9.562	***	0.532
H5: Top management support → business process performance	0.256	6.790	***	0.509
H6: Top management support → Project management practices	0.178	8.456	***	0.172
H7: Governance volatility → BPC project performance	0.170	3.670	***	0.061
H8: Governance volatility → business process performance	0.025	1.275	n.s.	0.066
H9: Governance volatility → Project management practices	- 0.051	1.725	n.s.	- 0.051
H10: External volatility → BPC project performance	0.045	1.759	n.s.	0.037
H11: External volatility → business process performance	0.033	1.685	n.s.	0.059
H12: External volatility → Project management practices	- 0.044	1.740	n.s.	- 0.043
H13: Target volatility → BPC project performance	- 0.313	11.557	***	- 0.110
H14: Target volatility → Business process performance	0.013	0.542	n.s.	- 0.006
H15: Target volatility → Project management practices	- 0.311	12.196	***	- 0.310
H16: Project management practices → BPC project performance	0.283	6.653	***	0.183
H17: Project management practices → Business process performance	0.173	5.486	***	0.076

H18: BPC project performance → business process performance	0.580	15.442	***	0.530
β: PLS Algorithm Path Weighting Scheme; t-value: bootstrapping with 130 cases, 2.000 subsamples; *: p < 0,05 → t-value 1,960; **: p < 0,01 → t-value 2,576; ***: p < 0,001 → t-value 3,291; n. s. = not significant				

Table 12. Path coefficients, t-values and effect sizes

More specifically, our results show that organizational support risks have a stronger influence on the overall BPC project performance. In detail, user participation impacts BPC project performance (H1) and project management practices (H3). Top management support has a critical influence on project management practices (H6), BPC project performance (H4) and process performance (H5). The external volatility shows a significant impact on BPC projects (H10). On the contrary, target volatility has strong influence on project management practices (15) and BPC project performance (H13). Governance volatility only has a significant influence on BPC project performance (H7). Hence, volatility risks influence project management practices and project performance but appear to have no direct impact on the process performance. Furthermore, our results also support the findings of Gemino et al. (2008) that project management practices have direct influence on BPC project performance (H16) and the changed process performance (H17). Lastly, our results also showed support for Jurisch et al.'s (2014) finding that the project performance has strong impact on the performance of the changed business process (H18). Hence, measuring BPC project success at the process level appears to be highly recommendable.

Figure 20 summarizes the results of the analysis with estimated path coefficients and associated t-values of the paths (Chin, 1998).

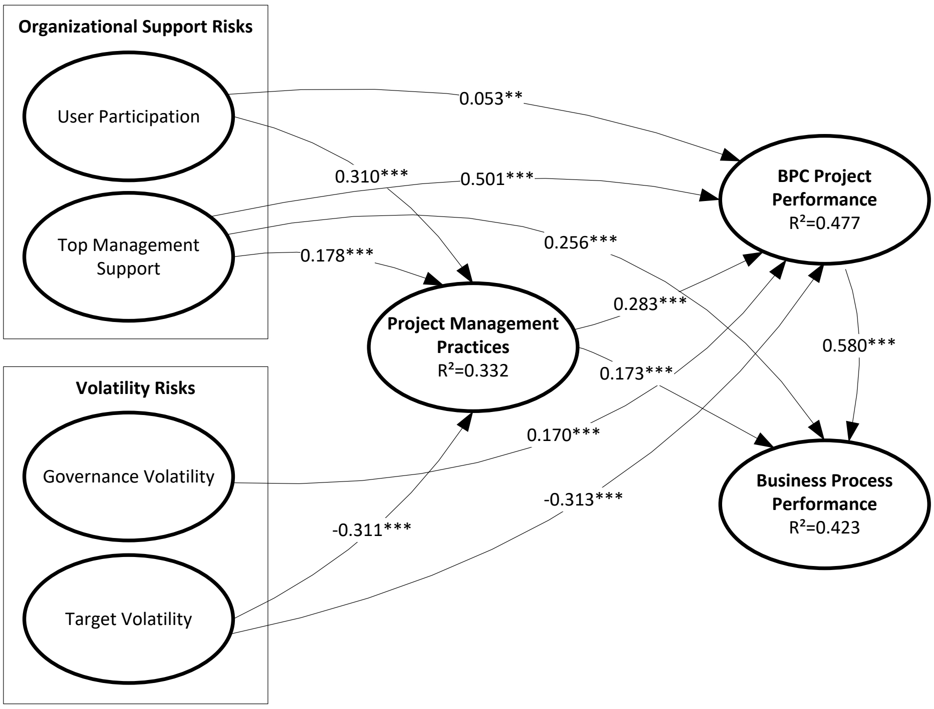

Figure 20. Emergent risks impacting BPC project and process performance

3.5 Discussion

Our results reported above make a number of contributions to research on emergent risks in BPC projects. First, our results suggest that organizational support risks have direct impact on BPC project performance, which indicate that higher user participation and higher top management support substantially improve BPC project performance. Furthermore, our results suggest that organizational support risks positively influence project management practices. These results thus partially confirm the findings reported by Gemino et al. (2008), who reported that organizational risks positively influences the project management practices, but on the other side do not have a direct impact on project product performance, which is in contrast to our findings.

Second, our results indicate that top management support positively influences business process performance, which is in line with Gemino et al. (2008). On the other hand, we could not support the hypothesis that also user participation directly influences business process performance, which is in contrast to findings of Gemino et al. (2008). The relationship between user participation and business process performance can be better explained by considering the mediating role of project management practices.

Third, our results indicate that there is no direct relationship between volatility risks and business process performance. However, this is also in contrast to findings of Gemino et al. (2008) who found that volatility risks have a direct impact on project process performance. Our results suggest that the relationship between volatility risks and business process performance can be similarly to previous point better explained by considering the mediating role of project management practices.

Fourth, our results show support for Jurisch et al.'s (2014) finding that the project performance has strong impact on the performance of the changed business process. Hence, measuring BPC project success at the process level appears to be highly recommendable.

With these results we established a more nuanced understanding of the emergent risks in BPC projects as well as empirically explained several relationships between emergent risks and business process performance and project performance. Furthermore, our study highlights the importance of studying moderating and mediating factors in BPC research to reconcile the magnitude of failure rates in BPC projects.

In interpreting the findings of this study, several limitations of case survey methodology need to be acknowledged. However, these limitations are very similar to those of other review methods. First, even we conducted an extensive literature search, we cannot guarantee that we identified all case studies. Furthermore, some case studies did not report the necessary information and thus, were not included in the case survey analysis. However, we are confident that any other case studies would not significantly affect our results. Second limitation refers to the publication bias, which means that significant results are more likely to be published than non-significant results (King & He, 2005). However, these published and significant results may not always be representative for the entire research population. Third, even though our coding results showed high inter-coder reliability, the process of designing scheme is bound to a certain degree of subjectivity. Any doubts in coding assignments were resolved by reaching a consensus. The fourth limitation refers to the sample size included in a case survey. According to King and He (2005) the statistical power of detecting a genuine effect size depends on the number of case studies included in a case survey. However, no information exists on the minimum sample size of a case survey. The last limitation of the case survey methodology is that it can be very time-consuming and cost-intensive to conduct. Even though Larsson (1993) argues that it is an inexpensive method, our own experiences suggest that the sampling and coding of case studies are rather resource-intensive stages.

3.6 Conclusion

This study was motivated by the insufficient understanding of emergent risks as one of the major cause for the high failure rates in BPC projects (Trkman, 2010; Cao et al., 2001; Strebel, 1996; Kliem, 2000). The findings reported above make four main contributions to research in BPC domain. First, we extended the theory of BPC by identifying emergent risks impacting BPC project and process performance. More specifically, our results suggest that user participation, top management support, governance volatility and target volatility are critical emergent risks in BPC projects.

Second, we provided a theoretical explanation of the effects of emergent risks on the BPC project and process performance. Since, this study empirically examined the nature and magnitude of relationships between organizational support risks, volatility risks and BPC project and process performance. This is a useful beginning in helping practitioners to obtain a better understanding of emergent risks when planning and performing BPC initiatives.

Third, our research makes a methodological contribution. More specifically, we have demonstrated the usefulness of including case survey methodology in BPC research, as a promising approach to the development or extension of theories in BPC research. This is in line with other authors (Glass et al., 1981; Hunter and Schmidt, 2004) who argue that case survey methodology enable researchers to estimate more reliable effect sizes than traditional review procedures, which in turn might increase summative validity of theories developed or extended in case studies. We thus posit that the case survey methodology can help BPC researchers to (1) establish summative validity for the theories developed in case studies (2) make these theories accessible to a wider BPC audience and thus increase their relevance and (3) enrich and strengthen the theoretical core of the BPC research community.

Last, by replicating the study of Gemino et al. (2008) in different domain, we further highlight the importance of replication studies in BPC research area. The need for replication has become apparent within medical science, where the reproducibility of the results have overturned their key results. Thus, reproducibility of results lies at the core of modern science.

4 A Conceptual Framework of Requirements for the Development of E-Learning Offerings from a Product Service Systems Perspective[7]

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Table 13. Fact sheet publication P4

Abstract. The term e-learning subsumes all forms learning where electronic media is used for the presentation and distribution of the course content. Although various guidelines and models exist, the development and operation of e-learning offerings has shown to be a difficult task. Often existing approaches focus on single aspects such as technical details or the content of teaching, while neglecting other aspects such as level of service requirements. As e-learning offerings are IT-based systems consisting of hardware, software and services that have to be considered from a lifecycle perspective, they exhibit similar characteristics as Product Service Systems. We, therefore, suggest designing e-learning offerings from a systems perspective. As a first step, we synthesize a requirements framework for e-learning offerings from the e-learning and PSS literatures. We enrich the framework with examples from a real-life e-learning offering and argue why the PSS approach is useful for the design of e-learning offerings.

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4.1 Introduction

E-learning is a form of learning where electronic media is used for the presentation and distribution of course content (Urdan & Weggen, 2000). E-learning is a major trend at universities and other educational institutions worldwide. Different approaches for the development of e-learning offerings have been proposed and their implementation has led to a variety of different e-learning systems (ADL, 2008; Hoppe, 2005). However, the existing approaches often focus on either the technical details or on the content of teaching. According to Penna and Stara (2007) such unilateral view on e-learning offerings leads to many e-learning failures. Other studies (cf. Thomas, 2003) show that focusing only on content details or on technical details lead to lower acceptance of the e-learning and have significant impact on the overall quality of e-learning offerings. Thus, several authors (Ehlers, 2004; Euler, Seufert, & Zellweger, 2008) call for a holistic approach for the development of e-learning offerings that accounts for multiple requirements domains, e.g., technical, content, level of service, at the same time.

Since e-learning offerings are IT-based systems consisting of hardware, software and services (Breitner & Hopppe, 2004) that have to be considered from a lifecycle perspective, they exhibit similar characteristics as Product Service Systems (PSS) (Burianek et al., 2009; Leimeister & Glauner, 2008). We, therefore, propose to see e-learning offerings through the lens of PSS. Thus, we can make use of a variety of contributions on systems engineering for the design of e-learning offerings and also better understand the user’s intentions of e-learning offerings through relating e-learning to research on service marketing.

As a first step for the development and operation of e-learning offerings as PSS, we derive a conceptual design framework of requirements consisting of five top-level slots combining project, teaching, functionality, lifecycle and level of service requirements. Our framework based on the results of a literature analysis in the e-learning and PSS domains as well as our experience from an e-learning development and operation project. The conceptual framework is described in detail in this article and examples from our e-learning project are given for each slot. For an initial verification of the framework, we surveyed 65 participants with different backgrounds (MIS and business) on several characteristics of the framework. We then argue why the systems approach is a useful lens on e-learning offerings and end with a conclusion.

4.2 Methods

Following the guidelines by Webster and Watson (2002), we start our search for relevant literature within the leading journals and conferences in the Information Systems discipline. We search in all Quality IS Literature stated in Levy and Ellis (2006) for the contributions based on following key words: Product Service Systems, PSS, e-learning models, e-learning standards, e-learning quality, PSS requirements, e-learning requirements, hybrid products, hardware, software and service engineering, e-learning quality standards. We also included scientific databases such as ‘Ebsco’, ‘IEEE Xplore’, ‘CiteSeerX Beta’, ‘Springer Link’ and ‘Google Scholar’ for the same words. The selected keywords resulted in a total of 236 documents. We screen and eliminate the duplicates and irrelevant documents manually. While ensuring the applicability in the context of e-learning offerings, we identify 23 documents as relevant.

Also, our experiences with a real-life e-learning offering, that we designed and developed at our university, contribute to the structure and design of the framework in many details. The e-learning offering is a strategic business simulation where students have run a bank and make complex decisions.

For an initial verification of the framework, we surveyed 65 students with the help of a semi-structured questionnaire. All the survey respondents were former participants in the business game. We deemed the participant group especially valuable, as all the participants both have a MIS or business background and are familiar with e-learning offerings.

4.3 Background

In this section we give an overview of literature in the PSS and e-learning domain, whereby we focus on the systems idea of PSS and aspects related to requirements engineering in both PSS and e-learning.

Product Service Systems (PSS)

PSS are defined as bundles of products and services combined into a system (Berkovich, Leimeister, & Krcmar, 2009). Products are tangible commodities that are manufactured to be sold, while services can be understood as activities done for others, which exhibit an economic value. PSS is a general term which is used in several industries, e.g., manufacturing and IT (Baines et al., 2007). IT-based service systems are a subgroup of PSS in the IT industry. Burianek et al. (2009) suggest defining PSS based on the following three characteristics:

(1) PSS are combinations of product and service components

A PSS is not a fixed combination of product and service components, but different combinations of products and services are possible. Customers who purchase a PSS are not interested in the single parts, but in a solution to their problem (Burianek et al., 2009). Moreover, a PSS cannot directly be attributed a value, but the provider makes a value proposition when offering a PSS.

(2) PSS are tailored to fulfill individual customer needs

PSS are designed to meet the customer’s individual needs (Becker & Krcmar, 2008; Leimeister & Glauner, 2008). The PSS provider has to offer activities of a customer-provider relational solution process. Those activities are comprised of requirements analysis, customization, implementation/ deployment and servicing/operations. The customer and the provider consequently enter a relational business connection (Burianek et al., 2009; Tuli, Kohli, & Bharadwaj, 2007).

(3) PSS are highly integrated

Integration refers to the technical-organizational combination of PSS components. The more inclusive a PSS becomes, the more important it is to fully adapt single components to each other as the number of compatibility constraints increases (Berkovich, Leimeister, & Krcmar, 2009).

E-learning

According to Urdan and Weggen (2000) e-learning is a form of learning where electronic media is used for the presentation and distribution of course content. E-learning has been viewed as synonymous with Web-based learning, Internet-based training, Advanced Distributed Learning, Web-based Instruction, Online Learning and Open/Flexible Learning (Khan, 2001). E-learning offerings consequently can be considered as a PSS or more specifically as an IT-based service system.

E-learning offerings have in common that different factors influence the success and users acceptance of the offering (Garzaldeen & Münzer, 2003; Hoppe, 2005; Selim, 2007). Some authors (ADL, 2008; Selim, 2007) point out that e-learning offerings nowadays need to account for interaction functionalities, e.g., chats or wikis.

Moreover, according to Euler, Seufert and Zellweger (2008) and Ehlers (2004), level of service requirements such as responsiveness and performance play an important role during the operational phase. An e-learning offering not satisfying the standard level of service requirements the student is used to would not be accepted.

Some authors (Baume, 2009; Euler, Seufert, & Zellweger, 2008) furthermore propose to embed the e-learning offering development in a project and to perform typical project management tasks such as developing a timetable and setting up a project controlling. Another important aspect is to develop the e-learning offering in close relation to the future user in order to best adapt to the users' requirements (Breitner & Hopppe, 2004).

4.4 A Conceptual Framework for Requirements of the Development of E-Learning Offerings

In this chapter, the conceptual framework of requirements for the design of e-learning offerings is derived and described. The proposed framework consists of five main slots *Project Requirements*, *Teaching Requirements*, *Functionality Requirements*, *Lifecycle Requirements* and *Level of Service Requirements* (cf. Figure 21).

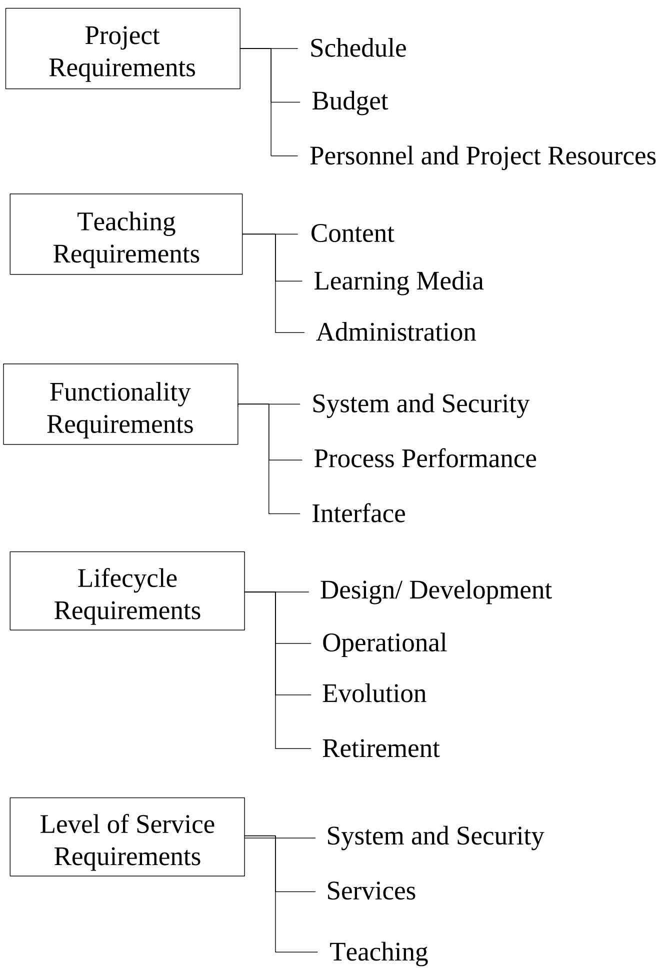

Figure 21. Conceptual framework of requirements for the development of e-learning offerings

4.4.1 Project Requirements

In the analyzed literature, we could identify requirements pertaining to schedule and budget (Boehm et al., 2004; DIN PAS 1032-1, 2004; IEEE, 1998), project staffing and project resources (DIN PAS 1032-1, 2004).We considered these requirements as project requirements because they relate to how projects are set up and implemented. According to Boehm et al. (2004), we define project requirements as general tasks and restrictions a project team has to fulfill or pay attention to during the project phase.

Schedule

Similar to authors in software and hardware engineering (Boehm et al., 2004; IEEE, 1998), as well as to the e-learning standard (DIN PAS 1032-1, 2004), we define schedule requirements as all important milestones and deadlines that must be met during the project phase.

Budget

Budget requirements are mentioned in hardware and software engineering (Boehm et al., 2004; IEEE, 1998). However, budget requirements and cost calculations also play an important role in the e-learning discipline (Breitner & Hopppe, 2004). We define budget requirements as all kinds of cash flows connected with the project.

Project Personnel and Project Resources

We define project personnel as all people being involved in the project during project time in terms of calendar months and project resources as well as material and equipment needed during the project phase (Boehm et al., 2004; IEEE, 1998).

4.4.2 Teaching Requirements

Authors from the e-learning literature suggest requirements related to content (Breitner & Hopppe, 2004; Selim, 2007), learning media (Jaspers, 1991; Selim, 2007) and administration (ADL, 2008; Rosenberg, 2001). From a systems approach, we argue to consider those domain requirements along with project or technical systems requirements at the same time. We, therefore, propose to define teaching requirements as all important tasks that have to be fulfilled during the curriculum planning and management as well as the lectures and that impose constraints on the e-learning offering.

Content Requirements

Some authors (Volery & Lord, 2000; Webster & Hackley, 1997) in the e-learning domain suggest content requirements related to course content, learning sequence and pace of learning. We define content requirements as all important requirements pertaining to the teaching content and its representation from a didactic perspective as well as the resulting constraints that are imposed on the system.

Learning Media Requirements

According to Selim (2007) and Jaspers (1991) the right form of learning media (e.g., text, language, video, simulation, or game) is necessary for a successful knowledge transfer. Learning media requirements include all requirements and constraints for the different kinds of multimedia applications that help to create meaningful e-learning environments from a didactic perspective as well as the resulting constraints that are imposed on the system.

Administration Requirements

Rosenberg (2001) and ADL (2008) suggest administration requirements regarding different lecturer tasks and student services (e.g., registration, counseling, advising and tutorial services). We define administration requirements as all kinds of recurrent non-lecturing tasks which support the successful course of an e-learning lecture as well as the resulting constraints that are imposed on the system.

4.4.3 Functionality Requirements

All contributions we analyzed from the hardware, software and service engineering disciplines propose requirements for system functions (Ullmann, 2003; White & Edwards, 1995), application capabilities (Boehm et al., 2004), functional requirements (IEEE, 1998), functions

(Liechtenstein, Nguyen, & Hunter, 2004), core elements (Lovelock & Wright, 2001), or requirements on how the results are achieved (Bullinger, Fahnrich, & Meiren, 2003). Similarly, authors from the PSS domain frequently mention functions or functional requirements (Burianek et al., 2009; Tuli, Kohli, & Bharadwaj, 2007). In the e-learning standard SCORM, offerings are divided into functional components, e.g., learning management systems and sharable content objects. We subsume all those requirements as functionality requirements. According to Boehm et al. (2004) and White and Edwards (1995), we define functionality requirements for the conceptual framework as features the e-learning offer has to provide as well as the supported services and its behavior. To reduce complexity, we divide this slot into system and security, process performance and interface requirements.

System and Security Requirements

We define system functionality requirements as all features related to material and immaterial components connected to the e-learning offering. This includes communication infrastructure (e.g., backup and recovery systems, network security and accessibility), learning management components (e.g., knowledge tests, features for learning progress monitoring), or collaborating learning functionalities (e.g., chats or wikis) (Breitner & Hopppe, 2004; Selim, 2007).

Process Performance Requirements

Process performance requirements account for all functionalities which relate to effectively managing the processes related to the e-learning system, such as change management, customizations, automation, or integrations with existing support systems. One example is the automation of administrative processes (such as participant list creation, group mailing) to support lecturers (ADL, 2008; Breitner & Hopppe, 2004).

Interface Requirements

Authors from all disciplines analyzed (ADL, 2008; Boehm et al., 2004; IEEE, 1998; Liechtenstein, Nguyen, & Hunter, 2004; Lovelock & Wright, 2001; Roman, 1985; White & Edwards, 1995) stress the importance of interface requirements. Thus, we define interface requirements for the conceptual framework according to Boehm et al. (2004) as the requirements which describe the interaction, exchange and communication of the system with users, hardware, software and services for input and output.

4.4.4 Lifecycle Requirements

Authors from hardware (Ullmann, 2003; White & Edwards, 1995) and service engineering (Bullinger, Fahnrich, & Meiren, 2003; Lovelock & Wright, 2001) differentiate between requirements which are important in the design phase and which are important in the operation phase. Moreover, software engineering authors (Boehm et al., 2004; IEEE, 1998) differentiate between design and evolution requirements and authors from the PSS (Burianek et al., 2009; Tuli, Kohli, & Bharadwaj, 2007) as well as e-learning discipline (Baume, 2009) distinguish development and operational requirements. Hence, we conclude that different requirements exist in different lifecycle phases. For the conceptual framework, we subsume these requirements as lifecycle requirements and divide the slot into design/development, operational, evolution and retirement requirements.

Design/ Development Requirements

Design/ development requirements are frequently mentioned in hardware (Ullmann, 2003; White & Edwards, 1995), software (Boehm et al., 2004; IEEE, 1998) and service engineering (Bullinger, Fahnrich, & Meiren, 2003; Liechtenstein, Nguyen, & Hunter, 2004; Lovelock & Wright, 2001), as well as in many e-learning standards (ADL, 2008; IEEE, 1998; IMS, 2005). We define design/ development requirements as all requirements that must be considered in the design and development phase of an e-learning offering, e.g., the use of a specific programming language or reference models for service blueprinting.

Operational Requirements

Operational requirements are mentioned in the hardware (Ullmann, 2003; White & Edwards, 1995) and service engineering literatures (Bullinger, Fahnrich, & Meiren, 2003; Liechtenstein, Nguyen, & Hunter, 2004; Lovelock & Wright, 2001). We define all requirements that must be fulfilled during the operational phase and all the resources needed to operate the e-learning offer as operational requirements. In our project, these were the required maintenance personnel and permanently needed resources such as IT and meeting rooms.

Evolution Requirements

Evolution requirements are suggested in hardware engineering (Boehm et al., 2004; IEEE, 1998), software engineering (Boehm et al., 2004; IEEE, 1998) and service engineering (Bullinger, Fahnrich, & Meiren, 2003; Liechtenstein, Nguyen, & Hunter, 2004; Lovelock & Wright, 2001). Moreover, authors from the e-learning (Baume, 2009) and PSS (Burianek et al., 2009; Tuli, Kohli, & Bharadwaj, 2007) domains emphasize the importance of growth and expansion. We subsume all those requirements as evolution requirements and define evolution requirements to take into account all foreseeable developments and future growth expectations.

Retirement Requirements

Retirement requirements are common in hardware engineering (Ullmann, 2003). We define retirement requirements of an e-learning offering as all requirements related to assigning personnel and material resources to new purposes. For example, we did not choose a physical but a virtual server for the operation of the e-learning offering as we can use the servers for other purposes after the shutdown of the business game.

4.4.5 Level of Service Requirements

Authors from various disciplines we analyzed suggest performance requirements (IEEE, 1998; Liechtenstein, Nguyen, & Hunter, 2004; Ullmann, 2003), service levels (Boehm et al., 2004), non-functional requirements (Roman, 1985; White & Edwards, 1995) and level of service requirements (Bullinger, Fahnrich, & Meiren, 2003; Lovelock & Wright, 2001). According to Boehm et al. (2004), we define level of service requirements as how well given requirements are performed. To reduce complexity, level of service requirements are subdivided into system and security, services and teaching level of service requirements.

System and Security

Authors in hardware engineering have proposed a variety of level of service and security requirements (Roman, 1985; Ullmann, 2003; White & Edwards, 1995). In software engineering, many authors refer to the term as „the -illities“, like „reliability“, „maintainability“ and „flexibility“. We suggest reverting to Garvin (1984) and Boehm et al. (2004) for e-learning offering level of service requirements, who identify and define level of system requirements such as performance, availability, maintainability, usability, reusability and system security.

Services

The service engineering discipline is nascent (Berkovich, Leimeister, & Krcmar, 2009). Moreover, level of service requirements for services are often considered at a very technical level. For this reason we refer to Zeithaml, Parasuraman and Berry (1990), who identified ten general level of service determinants: reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding and tangibles.

Teaching

As we consider e-learning offerings from a systems perspective, we also suggest including level of service requirements for teaching aspects. E-learning standards (ADL, 2008; IMS, 2005) frequently include the following requirements related to teaching and coursework aspects: evaluation of teacher’s didactical competency, teacher responsiveness, quality of content and learning material.

As next, we analyze the initial interaction between the identified requirements, which we summarize in Table 14.

	Project	**Teaching**	**Functionality**	**Lifecycle**	**Level of Service**
Project	-	-	-	-	-
Teaching	x	-	-	-	-
Functionality	x	x	-	x	-
Lifecycle	x	-	-	-	-
Level of Service	x	x	x	x	-

Table 14. Matrix of hypothesized effects between identified requirements

Project requirements are affected by all other identified requirements, as they pertain to the requirements and assumptions about the proposed e-learning offering and the needed resources. Level of service requirements affect teaching, functionality and lifecycle requirements, as they define and analyze how efficient given requirements are performed. Finally, functionality requirements affect teaching and lifecycle requirements as they define how an e-learning offering should serve and which functionalities and services it should provide.

4.5 Evaluation

For the evaluation, we used a semi-structured questionnaire consisting of a total of 16 questions. 4 questions regarded the overall framework completeness, intuitiveness and usefulness, as well as the usefulness to consider content and technical aspects at the same time. Answers were given on a 7 point Likert scale (7: strongly agree, 4: neutral, 1: strongly disagree). Another 6 Yes-No questions with additionally text fields asked for improvement suggestions. Finally, 6 questions pertained to the participants' personal backgrounds. The survey's objective was to get the students feedback and their impressions of the proposed framework. The students were given a handout with an overview of the framework and with written definitions of each category such as proposed in the main chapter. 65 students took part in our survey. All surveyed students were master degree students that participated in our business game course and had either a MIS (90.7%) or a business (9.2%) background. Most of the students (81.5%) already have work experience and 28 (43%) of them see themselves as "experienced" to "very experienced" in software and system development. The results from the survey are shown in Table 15.

Framework survey (n = 65)	**Average**	**Variance**
Completeness overall	5.2	1.2
Intuitiveness overall	4.6	2.1
Usefulness overall	4.8	2.1
Usefulness of considering content and technical aspects at the same time	3.9	4.1
	Yes/No Questions:	
Can you think of categories not included in the framework?	Y=29	N=36
Can you identify requirements that could not be assigned to any of the requirements categories?	Y=16	N=49
Can you identify requirements that would fit into several requirements categories?	Y=9	N=56
Can you identify unnecessary requirements categories?	Y=14	N=51
Would you suggest renaming one or several requirements categories?	Y=9	N=56

Table 15. Survey results

The overall results indicate that the respondents found our framework overall complete (mean 5.2), intuitive (mean 4.6) and useful (mean 4.8). The participants slightly disagreed to consider content and technical aspects at the same time (mean 3,9). 29 respondents (44.6%) proposed new requirements categories like security, user, or support. 16 students (24.6%) named requirements they had trouble to assign to a category, e.g., usability, student evaluation, or change management. 9 students (13.8%) suggested change management, usability, administration and evaluation as requirements that would fit into several requirements categories. Moreover, as 9 students proposed, we renamed a former Content Requirements category into Teaching Requirements, as those requirements do not only relate to the learning content, but to the overall teaching affairs.

Especially with regard to questions one to three, the participants attested that our framework is useful for the design of e-learning offerings. For the next version, we are going to incorporate the participants' feedback into the framework.

4.6 Discussion

As we have shown, e-learning offerings are IT-based service systems that comprise hardware, software, service components (Breitner & Hopppe, 2004). Therefore, e-learning offerings qualify as an instantiation of PSS, which developed from the idea that customers are not interested in products or services per se, but in solutions to their individual needs (Baines et al., 2007; Leimeister & Glauner, 2008). The idea of PSS is strongly related to the emerging idea of service systems and the Service Dominant Logic (SDL) (Spohrer & Maglio, 2007; Vargo & Lusch, 2004).

The original idea to consider e-learning offerings as PSS developed when we performed a literature analysis on e-learning and when we came to the conclusion that many existing contributions focus on specific details of an e-learning offering only. Similar to Ackoff (1971), who argues that a systems approach always needs to focus on the whole system and not the single parts, we suggest approaching the design, development and operation of e-learning offerings from a systems perspective. Our theoretical contribution is, therefore, that we connect the e-learning domain to the PSS and systems approach and, the other way round, that we propose e-learning offerings as a practical example for service researchers.

That said, this research is not without its limitations. We need to show in more detail that e-learning offerings have the same characteristics as the underlying fundamental premises of the SDL, e.g., that providers only can make value propositions, that customer and provider enter a relational business connection and that both are resource integrators. Although our framework is a practical contribution, more research is required to refine its structure and categories. Experiences form the application of the framework in the field might deliver useful insights for further development. Also, the framework is meant to be used for the requirements elicitation at the beginning of e-learning projects to stimulate thinking, focus effort and check for thoroughness. In the future, the framework might be more detailed to also be used in later design phases.

4.7 Conclusion

The conceptual five-part framework is derived from literature on e-learning, PSS and the PSS related disciplines. We moreover enriched the framework with experiences and examples from an e-learning project. Five top-level slots were designated for the framework, including project requirements, teaching requirements, functionality requirements, lifecycle requirements and level of service requirements. In a first step to validate the framework, we also surveyed 65 students with MIS and business backgrounds.

This paper contributes a novel, single expression of requirements for e-learning offerings based on a PSS perspective. One fundamental idea underlying the PSS perspective is the system approach, which is the consideration of multiple design, development and operations aspects at the same time. With our framework, we intend to bring together the e-learning and PSS domains. Moreover, we hope that researchers might use the framework as a starting point for the development of e-learning requirements engineering models adopting a systems approach. Practitioners might find or framework useful in collaborative requirements workshops and other settings.

5 Simulation Model for Cost-Benefit Analysis of Cloud Computing versus In-House Datacenters[8]

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Status	Accepted

Table 16. Fact sheet publication P5

Abstract. For many organizations it is difficult to determine the total costs caused by offering own services in the cloud as well as to compare them with the costs caused by an in-house datacenter. In practice, some models exist that support organizations in analyzing costs. However, these models are mostly static and do not consider the dynamics of cost development when using cloud computing. The purpose of this paper is to design and develop a simulation model that covers such dynamic aspects and supports decision makers in analyzing cost-benefits of cloud computing versus own datacenter. The model is based on a theoretical framework for IS and applies the method of system dynamics.

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5.1 Introduction

As Gartner predicted, cloud computing is currently on the “peak of inflated expectations” (Fenn, Gammage, & Raskino, 2010). Cloud computing is a concept where IT resources and services are provided via Internet (M. Boehm et al., 2009), highly scalable, on demand, web accessed IT-resources, costs and flexibility benefits due to standardization, modularization and virtualization using scaling effects (Anonymous, 2011). Cloud computing does not only imply the applications and services delivered over the Internet, it also refers to the hardware, software and infrastructure of the database performing the demanded services (Armbrust et al., 2009). Some researchers distinguish between three types of cloud computing: Software as a Service (Saas), which covers application services like Salesforce; Platform as a Service (PaaS), such as developer platforms like the Google AppEngine; and Infrastructure as a Service (IaaS), such as Amazon Web Services (Mei, Chan, & Tse, 2008; Weinhardt et al., 2009).

There is a debate whether cloud computing is a cost advantage or not compared to own datacenters (Golden, 2011). For instance, for service providers, one of the most frequent questions is whether it is more economical to move the existing datacenter-hosted services to the cloud, or to keep them in the datacenter (Armbrust et al., 2009). This means, that one of the service provider´s primary criterion for such a decision is costs. However, for many organizations it is relative complicated to determine the costs caused by offering own services in the cloud as well as to compare them with the costs caused by an own datacenter (Golden, 2009). In practice, some models exist that support organizations in analyzing and comparing costs, such as “Amazon Simple Monthly Calculator.

However, these models are mostly static and do not consider the dynamics of cost development by using cloud computing, such as additional resource request for known “peaks” for a desired time span. To close this gap, we develop a simulation model, which covers the dynamics of cost development and assists decision makers by analyzing costs-benefits associated with cloud computing and own datacenter. This simulation model is based on system dynamics approach. System dynamics is useful for identifying key decision factors and relationships between them and helps to perform decision making in a more efficient way (Gaul et al., 2005). System dynamics is a simulation methodology for modeling dynamic and complex systems; i.e. systems that change continuously over time. Cloud computing also shows continuous changes such as customer and company new demands.

The remainder of this paper is organized as follows: In section 5.2 we describe our research method. In section 5.3 we analyze the literature regarding cost, risks, advantages and disadvantages associated with cloud computing and own datacenter. In section 5.4 we propose our system development methodology for the simulation model. We conclude with a discussion and ideas for further research in section 5.5.

5.2 Research Method

To identify the main components of the simulation model for cloud computing costs analysis, we first conducted a literature review (vom Brocke et al., 2009; Webster & Watson, 2002). Our scope was to account for contributions regarding costs, risks, advantages and disadvantages in the cloud computing domain and in operating own datacenter. The proposed simulation model is based on a theoretical framework for IS development process proposed by Nunamaker, Chen, & Purdin (1990), incorporated with the method of system dynamics (Sterman, 2000). For an initial verification of the simulation model we conducted six structured interviews with experts in the field of cloud computing and virtualization domain.

5.3 Literature Review

In this section we give an overview of literature in the cloud computing and own datacenter.

5.3.1 Cloud Computing

5.3.1.1 Costs Associated with Cloud Computing

For many organizations it is relative complicated to determine the exact total costs caused by offering own services in the cloud as well as to compare them with the costs caused by an own datacenter (Golden, 2009). For instance, the average cost per year to operate a large datacenter is usually between $10 million to $25 million (Hurwitz et al., 2011), while according to Alford and Morton (2009), an organization with 1,000 file servers faces average costs in the cloud between $22.5 million and $31.1 million.

According to Durkee (Golden, 2009), while running into the arguments regarding cloud economics, the first controversy to solve is "*OpEx vs. CapEx*". This refers that running an application (or a service) with own resources at the own datacenter requires capital expenditure ("*CapEx*"), while using external cloud computing resources and paying just for its use means having operating expenditure ("*OpEx*") (Golden, 2009, 2011). In other words, the question arises whether converting capital expenses to operating expenses (CapEx to OpEx) is a cost advantage or not (Armbrust et al., 2009). For instance, having an own datacenter means having costs for power, cooling, building, network, storage infrastructure, etc. (Armbrust et al., 2009; Golden, 2009; Greenberg et al., 2009). On the other side, running the service in the cloud produces other kind of cost factors, which will be described as follows.

Expensive and slow data connection: Service providers have to develop and transfer the data of the service or application they want to offer to the cloud. Due to low bandwidth and expensive connection fees, the data transfer could be slow and cause high costs to the organization (Gray, 2003).

Operation costs: Using virtual machines instead of physical machines does not necessarily mean that all the costs associated with hardware and software operations are transferred to the cloud computing provider. Depending on the level of virtualization, some (or even all) of the costs related with software and hardware management may remain (i.e. upgrades, applying patches, etc.) (Armbrust et al., 2009).

Migration: Another issue is the costs caused by the software complexity and the migration of the data from a legacy enterprise application into the cloud. Although migration is a one-time task with a given cloud computing provider, the effort and money invested can be notable (Armbrust et al., 2009).

Possible failure and data loss: A temporary breakdown could cause data loss and other scenarios that may produce major damages and extra costs.

Platform costs: The application-operating environment causes generally annual maintenance costs (Hurwitz et al., 2011).

Backup and archive costs: These costs depend on the backup strategy implemented (Hurwitz et al., 2011).

5.3.1.2 Risks Associated with Cloud Computing

Although cloud computing shows a number of benefits for many organizations, there is still a constellation of risks associated with it. According to Heiser and Nicolett (2008), cloud computing has "*unique attributes that require risk assessment in areas such as data integrity, recovery and privacy and an evaluation of legal issues in areas such as e-discovery, regulatory compliance and auditing*". Moreover, professionals are conscious of this situation: as ENISA shows in their study, around 45% of IT professionals believe that risks involved in cloud computing outshine any benefits (ENISA, 2011). Catteddu and Hogben (2009) identify three main risk categories associated with cloud computing: 1) Policy and organizational risks, such as lack of standards and solutions, loss of knowhow, or lack of transparency; 2) Technical risks, such as uncontrolled backup system, data deletion, or loss of governance; 3) Legal risks, such as data protection, or copyright and software licensing risks.

5.3.1.3 Advantages of Cloud Computing

There are a number of advantages and potential benefits for organizations that run their applications and services in the cloud. One of the most known advantages is the cost reduction, which according to Zeitler (2009), results due to low IT infrastructure and software costs. Moreover, organizations implementing cloud computing report cost reductions of 30 percent (Herrmann, n.d.). Besides the financial factor, there are other related benefits. For instance, Erdogmus (2009) describes other advantages of cloud computing as “scalability, reliability, security, ease of deployment and ease of management for customers, traded off against worries of trust, privacy, availability, performance, ownership and supplier persistence”. Some of these issues are discussed as follows (Braun et al., 2009; Jansen & Grace, 2011; Weinhardt et al., 2009):

Scalability and flexible infrastructure: Cloud computing offers the possibility to scale the infrastructure with the demand for peak loads and seasonal variations, allowing greater availability for both customers and partners.

Resource management: Service providers can use more flexible and efficient resources like servers, storage and network resources by using virtualization technology in cloud computing.

Consolidation: Resources such as server, storage, databases, etc. can be used more flexible and efficient by using virtualization in cloud computing. Consequently, less physical components are needed and therefore both amount of space and costs are saved.

Energy efficiency: Cloud computing enables energy efficiency due to reduction of physical components.

Backup and Recovery: The backup and recovery options of a cloud service may be more efficient than those of an organization, since copies are maintained in different geographic locations, which makes the backup procedures more robust and faster to restore.

5.3.1.4 Disadvantages of Cloud Computing

In the last section we presented the advantages of cloud computing. Nevertheless, there are a number of drawbacks related with it. However, one of the most known and also one of the most wicked disadvantages of cloud computing is the security and privacy concern. Therefore, in this section we summarize the drawbacks and disadvantages an organization has to face while offering its services in the cloud (Braun et al., 2009; Jansen & Grace, 2011; Kelson, 2009).

System complexity: Compared to a traditional datacenter, cloud computing environments can be very complex due to the number of components and their dispersion. Moreover, the number of possible interactions between the components increases the level of complexity.

Shared environment: Service providers that offer their services in the cloud typically share the resources and components with other unknown cloud users. Consequently, the risks and threats increase producing a drawback for the offered services.

Remote administrative access: Compared to own datacenter, where the applications and data are accessed from the organization´s Intranet, organizations with services in the cloud have to face increased risk from network threats due to remote access.

Loss of control: Migrating the data in the cloud means transferring control to the cloud provider of both information and system components that were previously under the organization´s control. Consequently, by loosing control of physical as well as of logical aspects, the organization also losses the ability to set priorities, weigh alternatives and think about changes regarding security and privacy issues.

For many organizations, the advantages of cloud computing far outweigh the disadvantages, for other, the disadvantages still outshine any benefits (ENISA, 2011).

5.3.2 Datacenter

5.3.2.1 Risks Associated with Own Datacenter

When considering the option of offering services in the cloud, a provider should not only be aware about the risks associated with cloud computing, but also with the ones related with owning a datacenter. According to Dines (2011), the primary risk associated with having an own datacenter is the capacity bottleneck. Running out of capacity means having high costs and in extreme cases, it "*requires an unexpected data center move, which is not only expensive but also potentially disruptive*". On the other side, having too much capacity could also be a risk, since IT infrastructure is most effective at peak load, making the datacenter inefficient (Dines, 2011). Moreover, besides of facilities, there are also other areas of risks while running an own datacenter, such as operations, monitoring (Witt, 2011), natural disasters and terrorism.

5.3.2.2 Advantages of Datacenters

Although many organizations decide to move their services to the cloud due to economic issues, there are still many reasons why organizations should keep their services running in their own datacenters (Geada, 2011; Jansen & Grace, 2011; Witt, 2011):

Visibility: Having direct access to all the infrastructure components like hardware, software and networking allows a better overview and the possibility to identify and mitigate any issues and systemic failures that crop up.

Control: Having the services running in the own datacenter enables greater control over the infrastructure and resources and therefore the access to the platforms can be restricted to direct or internal connections.

Less complexity: Datacenter are less complex since running the services in the own datacenter means having fewer components and therefore fewer interactions between them. Moreover, all physical components are located in the same place.

Optimization: Having an own datacenter gives the possibility to leverage and share existing place; i.e. having the IT department working in close proximity to the data center floor for a low cost.

Usage of knowledge: Datacenters are normally run by professionals with experience and expertise.

5.3.2.3 Disadvantages of Datacenters

Nowadays there are many organizations that still build and maintain their own datacenters even though that is not part of the core expertise of the company (Khajeh-Hosseini, Sommerville, & Sriram, 2010). As a result, there are a number of datacenters that are operated inefficiently (Weissberger, 2010). Absence of expertise by running own datacenters also produces a number of other disadvantages that will be described as follows (Armbrust et al., 2009; Chappel, 2011; Khajeh-Hosseini, Sommerville, & Sriram, 2010):

Inefficiency: Since a service provider has to provide enough resources to deal with peak times, the average utilization rate of datacenters ranges from just five to twenty percent.

Costs: It is predicted, that the costs of datacenter facility and energy usage will become significantly larger than the actual server procurement costs.

Scalability: Running an application or service in own datacenter makes it difficult to handle a rapidly growing load.

Environment: The impact of datacenters on the environment is currently receiving negative attention.

5.4 Theoretical Framework

The purpose of this research is to design and develop a simulation model that supports decision makers in analyzing costs associated with cloud computing and own datacenter. The proposed simulation model is based on a theoretical framework for IS development process (Nunamaker, Chen, & Purdin, 1990), incorporated with the method of system dynamics (Sterman, 2000).

The theoretical framework (cf. Figure 22) consists of five stages: construction of simulation model for costs analysis, development of system architecture, analyzing and designing the system, building the prototype system and evaluation of the system. In the following we describe each stage in more detail.

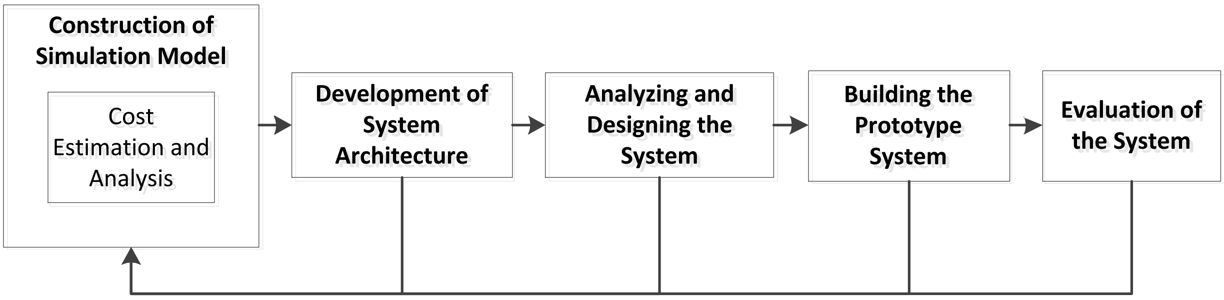

Figure 22. Theoretical framework for the simulation model

5.4.1 Phase 1: Construction of simulation model for costs analysis

First, a simulation model for cost-benefit analysis for cloud computing versus own datacenter is constructed as a kernel of the system.

5.4.1.1 Cost Estimation and Analysis

To analyze the costs-benefits of cloud computing and own datacenter, we apply the Total Cost of Ownership (TCO), since TCO considers not only the investment cost, but also cost over time for operation and maintenance. TCO is generally used as a means of addressing the real costs attributing to owning and managing an IT infrastructure in a business (Koomey et al., 2008).

To operate an own datacenter, usually companies are confronted with significant investment in capital outlay and ongoing costs. Company must acquire the required hardware such as server, network equipment, the required software, e.g. in the form of operating system license and the infrastructure such as uninterrupted power supply, cooling, or internet connection. Additionally, company must also account for the costs in computer room, such as costs for room square meter, fire detection and protection systems, or raised floor, as well as the ongoing costs for the administration. These costs usually depend on the average performance of server and network components in kW and the desired tier level (Koomey et al., 2008).

In contrast to own datacenter, by cloud computing the company need neither own server nor own datacenter. Companies no longer require the large capital outlays in physical hardware and the administration expenses to operate and maintain it. Infrastructure as a Service (IaaS) is mostly offered by providers such as Amazon EC2, Microsoft Azure, or force.com. Since, cloud computing makes use of pay-per-use concept, the companies can get results as quickly as their programs can scale. However, the number of IaaS provider increases, thus, it is necessary to determine which cloud services meet the technical requirements a company needs. Besides cost-benefit analysis, company should also determine the security and legal aspects of offered cloud services, as they play an important role for business continuity.

5.4.2 Development of System Architecture

A good system architecture is understood as a road map for the systems building process by placing components into perspective, specifying their functionalities and defining the interrelationships between system components (Nunamaker, Chen, & Purdin, 1990). Our system architecture (cf. Figure 23) consists of two main fragments. The first fragment represents the simulation model, where the mathematical formulations of costs computations are implemented. It is divided into two main modules: costs module for cloud computing and cost module for own datacenter. The modularity concept enables us to use the modules in a different context for multiple customers. The second fragment represents the user interface, where the evaluators can estimate the costs. After their input, we can start the simulation and they can analyze their outputs regarding their inputs with the help of chart and graphs.

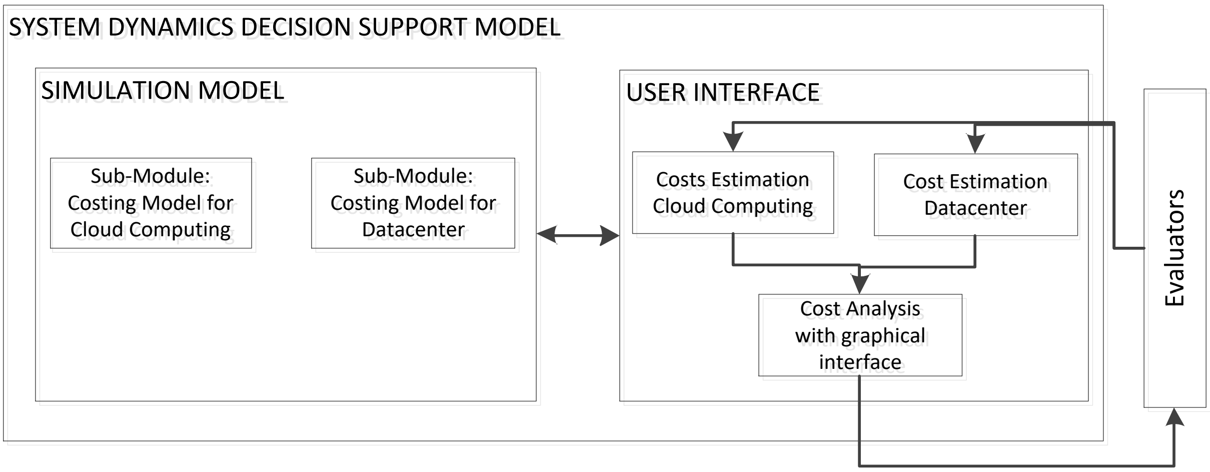

Figure 23. System architecture

5.4.3 Analyzing and Designing the System

In this phase, we determine the model components and the development platform. This involves the understanding of the studied domain, the application of relevant scientific technical knowledge and the creation and selection of various alternatives (Nunamaker, Chen, & Purdin, 1990). After identifying the model components, we can determine the interactions and interrelationships among them. In this phase, we also assign the mathematical formulations for costs calculations.

5.4.4 Building the Prototype System

In this phase, the system architecture is transformed into a prototype model. Implementation of a prototype system is used to demonstrate the feasibility of the design and the usability of the functionalities of a system development research project (Nunamaker, Chen, & Purdin, 1990). Based on the mathematical formulation and identified interrelationships between the model components, we can build our simulation model. For building the simulation model, we choose the simulation approach system dynamics, since this method can be used by identifying key decision factors and their interrelationships (cf. Figure 24). In following, we explain the simulation modules.

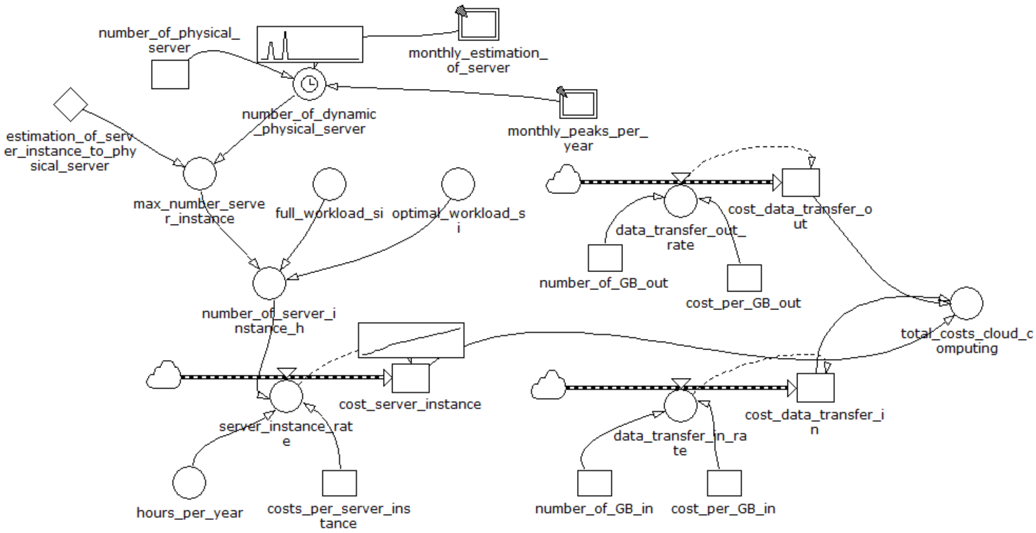

Figure 24. Cost module for cloud computing

To estimate the costs for cloud computing instance, we first need to estimate how many virtual server instances offered by the IaaS provider equal to a real server. We assume that two instances correspond approximately to the power of one physical server. Then we calculate the required number of server instances per hour. The final costs for server instances are calculated as product of “number of server instances”, “hours per years” and “costs per server instances”. In addition to server costs, we also must take into account the costs for the data transfer, in order to obtain the final costs for cloud computing instance. Based on the real values, we calculate for the data transfer with 0.05 Euro/GB for incoming data and 0.10 Euro/GB for outgoing data. The total costs of cloud computing instance are then calculated as sum of “costs for server instance”, costs per incoming and outgoing data transfer. To cover the dynamic development of costs for required resources, we incorporate in our simulation model the *step* function. This function allows company to exactly specify the known “peaks”. Let assume, a company knows that every August and December, in the first two weeks they need additional resources. With the help of this function, company can specify the exact days, hours, or month for the increased resources demand. We also applied this function to the variable “hours per year”; i.e. company can also specify individual dynamic usage time span. The simulation model then considers these “peaks” and calculates the costs over defined time span.

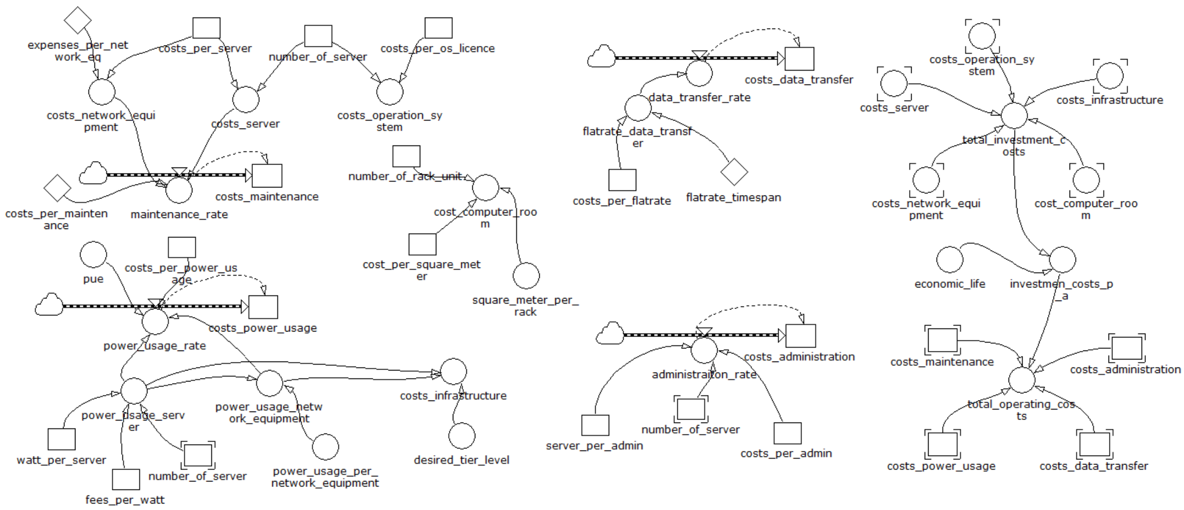

Figure 25. Cost module for in-house datacenter

To estimate the costs for server, we need to consider the initial cost of server, operating system licenses and additional network equipment. The costs for server are calculated as product of “number of required server” and “initial costs for server”. The costs for operating system licenses consist of “number of required server” and “costs per operating system license”. The costs for additional network equipment are calculated as product of “number of server” and “the expenditures of network equipment”. The expenditures of network equipment usually consist of 10 to 30 % of the costs of server. Additionally, we need to calculate the ongoing maintenance costs for server and network equipment. We estimate the costs for infrastructure as sum of “power usage server”, “power usage network equipment” multiplied with the costs of the desired tier level (Koomey et al., 2008). Additionally, we need to consider the power usage of the infrastructure. We need first to determine the power usage effectiveness (PUE), which is given by: PUE = Total Facility Power/ IT Equipment Power (Belady et al., 2008). The PUE can range from 1.0 to infinity, whereas 1.0 indicates 100% efficiency. The realistic PUE values are in the 1.3 to 3.0 range (Belady et al., 2008). To calculate the costs for the administration, we need to estimate how many servers one administrator can maintain. This depends on the size of datacenter. To obtain the final administration costs, we first divide the “number of server” through “the number of estimated server maintenance per administrator” multiplied with “the costs for one administrator”. For the data transfer costs, many companies rely on the flat rates. After estimating the costs for hardware, software, infrastructure, administration and data transfer, we can sum all these costs to obtain the total costs for data center.

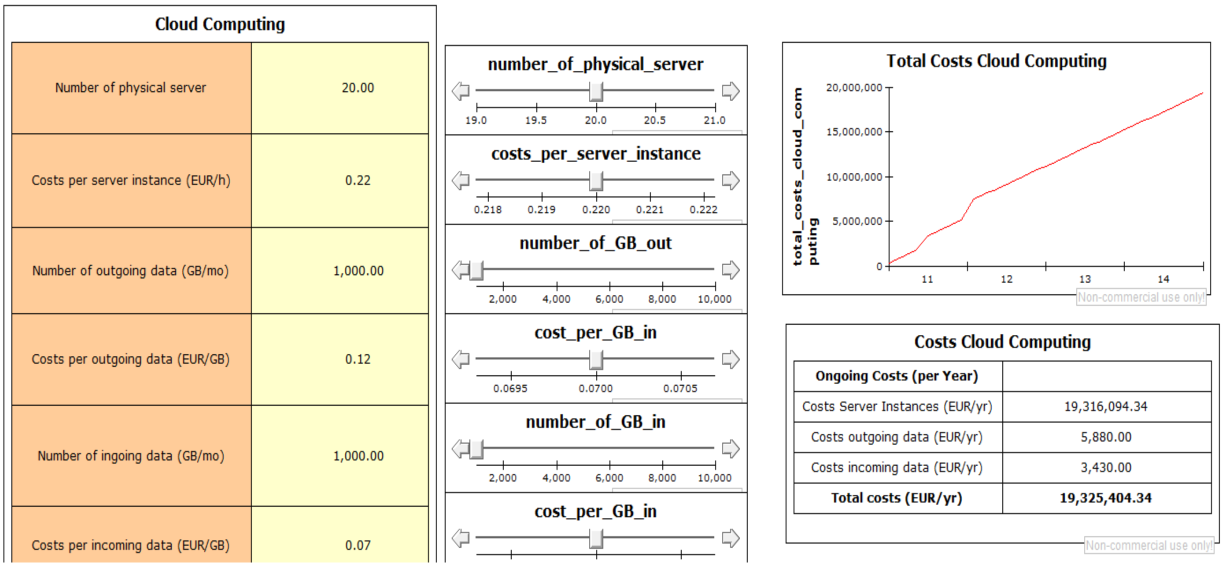

Figure 26. Overview of an user interface for cloud computing

Decision makers can change the values in the user interface, where we list the key influencing values for cloud computing and own datacenter. For example, user can modify the number of required components, such as server or licenses, or modify the costs for data transfer flat rate. In this user interface they can analyze the costs between own data center and cloud computing with the help of charts and graphs. The simulation model allows them to simulate different scenarios for different time span.

5.5 Evaluation of the System

To evaluate the simulation model, we performed an initial verification. For this purpose, we conducted six structured interviews with experts in the cloud computing and virtualization field. Through this verification, we capture the information whether the experts like or dislike the simulation model and whether it covers their needs or not. This verification ensure that the simulation model covers all functions that meets the users' requirements and help them to analyze the costs and risks associated with the decision whether to host services in cloud computing or whether to operate own datacenter. All evaluators are potential users of the model and one of them has knowledge in system dynamics. According to Gasching et al. (1983), evaluations by potential users help to determine the utility of a system, such as easy of interaction, its efficiency, or whether it produces useful results.

The overall results indicate that the experts found the simulation model "useful", "intuitive" and "complete" at first sight. All interviewees appreciate the modular separation of user interface. They like the separation between own datacenter and cloud computing, since this allows them to use the model only for specific domain. They also appreciate the "analysis user interface" where they found the costs comparison for both domains. Moreover, three experts stated that they like the presentation of results in "analysis user interface", as we used charts and time graph. Four interviewees agreed that they conceive of applying the model in their daily work. The remaining two experts do not agreed with the idea that cloud computing is not associated with onetime costs investments. They suggest to also to account for onetime investments such as licenses for Firewall, or costs for infrastructure setup such as internet connection. For the next version, we are going to incorporate the evaluator's feedback into the simulation model.

5.6 Conclusion and Outlook

We propose a simulation model for cost-benefit analysis of cloud computing versus own datacenter. This model is intended to fill the gap where a cost model that covers dynamic issues for cloud computing, is lacking. Practitioners will find the proposed simulation model useful by analyzing cost-benefits between cloud computing and own datacenter, as well as by analyzing different scenarios virtually before transferring them into the real world. Researchers can use the proposed model for testing different types of hypothesis and deriving recommendations for further actions. However, this research is not without its limitations. In this paper, we only proposed simulation model that considers costs for cloud computing and own datacenter. Thus, in the future, the simulation model might be more detailed to also be used for analyzing not only the economic impact but also organizational, as well as how is IT provisioned and used. In future work the authors will concentrate on extending the proposed simulation model to also account for other domains.

6 Towards Prioritizing IT Solution Developments through System Dynamics and Fuzzy Logic[9]

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Table 17. Fact sheet publication P6

Abstract. IT solutions are integrated bundles of hardware, software and services that create value for the customer by meeting their individual business needs. We found, that handling IT solutions is complex which results in several challenges that confront decision makers by developing IT solutions, such as the adaption of IT solution components to each other, or the integration to the customer's environment. To overcome these challenges, we propose a simulation model for prioritizing IT solution developments. The proposed model combines system dynamics and fuzzy logic and is based on a decision framework, which we derive from a broad literature review. To show the model applicability, we apply it by a mid-sized German company. The simulation results show the priority ranking of IT solution developments. Based on these results decision makers are able to determine the developing and integrating sequence of IT solutions.

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6.1 Introduction

Today's highly competitive marketplace redefines the way many companies do business (Simpson, 2004). The new way of competitive advantage is the offering of products in combination with services (Galbraith, 2002; Mont, 2002). An example of such combinations represent IT solutions, as they are provided through collaboration of multiple tangible and intangible resources managed by the provider that create value for the customer by meeting their individual business needs (Böhmann, Langer, & Schermann, 2008; Herzfeldt, Schermann, & Krcmar, 2010; Vargo & Lusch, 2004). Tangible resources include hardware (e.g. storage or network elements) and software components (e.g. application software), intangible resources consist of services (e.g. customization). An example of an IT solution is the development, integration, operation and support of a collaboration platform.

Due to competitive significance, several authors have made demands on IT solutions (e.g. (Berkovich et al., 2009; Böhmann & Krcmar, 2007; Herzfeldt, Schermann, & Krcmar, 2010)). These contributions are mostly focusing on requirement processes, or modularizing and designing IT solutions. However, there is only little theoretical guidance on prioritizing IT solution developments. Even though, prioritizing is seen as one of the most important step in IT solution development (Tukker & Tischner, 2004). Since, prioritizing of complex solutions is important by coordinating the company's business strategy with development competencies and by collaborating with customers and other external partners (Tan et al., 2010). Decision makers that face decisions in developing IT solutions are furthermore confronted with some challenges that are associated with IT solutions.

First, handling IT solutions is complex, as IT solution components do not only need to be adapted to each other, but also need to be integrated into customers' business processes and IT infrastructure (Berkovich, Leimeister, & Krcmar, 2009; Galbraith, 2002; Gräßle et al., 2010; Herzfeldt et al., 2011); i.e. interfaces and interdependencies have to be considered. This development process is shaped by a number of interactions and interdependencies that exist inside the customer organization, between the organization and its environment.

Second, IT solution decision makers need to consider a host of different dynamic variables and wide variety of factors, such as companies' and customers' strategies, companies' resources, or technological opportunities and derive the objectives based on these internal and external factors for a successful IT solution development (Berkovich, Leimeister, & Krcmar, 2009; Herzfeldt, Schermann, & Krcmar, 2010). These characteristics of the development process are often difficult to predict, as they often display complex dynamic feedback (Sterman, 2000; Warren, 2002), such as changing customer or market needs.

Third, IT solution developments are affected by many uncertainty-causing elements, such as the right IT solution combination to be offered, or the right time to be developed and integrated into customer environment (Berkovich, Leimeister, & Krcmar, 2009; Böhmann & Krcmar, 2007). Moreover, uncertainties influence costs over the whole IT solution development process (Revero & Embelmsvag, 2007). According to Spender (1993) uncertainty is an information defect. It arises from internal and external sources such as technical management, or commercial issues (Buyukozkan & Feyziouglu, 2004).

Fourth, IT solutions are tangible and intangible in nature (Böhmann, Langer, & Schermann, 2008; Vargo & Lusch, 2004). Thus, in many cases, economic measures cannot be applied directly, but subjective judgments are more convenient to use.

To overcome these challenges we propose a simulation model that assists decision makers in prioritizing IT solution developments. Based on these priority rankings decision makers are able to determine the developing and integrating sequence of IT solutions into customer's environment. The proposed simulation model combines system dynamics and fuzzy logic. Since, system dynamics can be used in complex and dynamic settings; i.e. in context where analytical solutions are too complex or not known (Madachy, 2008). System dynamics can be helpful by identifying key decision factors and interrelationships between them and help to perform the decision making process in a more efficient way (Gaul et al., 2005). System dynamics is a simulation methodology for modeling dynamic and complex systems; i.e. systems that change continuously over time. The prioritizing of IT solution developments also shows continuous changes such as organization's experience, or customer business demands. In turn fuzzy logic can be used for decisions or problems where a source of vagueness is involved and where information is uncertain (Zadeh, 1965).

As a first step for the prioritizing IT solution developments, we derived a decision framework consisting of five main steps: objectives setting, analysis, generating IT solutions, screening and evaluating IT solutions and prioritizing IT solutions. Our decision framework based on the results of a literature analysis in three relevant disciplines: new product development, new service development and decision-making processes. The proposed simulation model for prioritizing IT solution developments is based on this derived framework. Since, the framework is of wide scope, the proposed simulation model in this paper covers only evaluation and prioritization of IT solutions.

The remainder of this paper is organized as follows: In section 6.2, we describe our research method. As research in IT solution is rather nascent, we analyze development processes from literature in the relevant disciplines: new product and new service development. We enlarge our analysis to account for contributions from strategic management such as decision-making and derive a framework for IT solution developments in section 6.3. In section 6.4 we propose our simulation model based on the derived framework and in section 6.5 we show its applicability in a case study. We conclude with a discussion and ideas for further research in section 6.6 and 6.7.

6.2 Research Method

Following the guidelines by Webster and Watson (2002), we start our search for relevant literature within the leading journals and conferences in the Information Systems discipline. We search in all Quality IS Literature stated in Levy and Ellis (2006) for the contributions based on following key words: new product development, new service development, decision making, portfolio selection, combinations of these words, as well as German translations of these words. We also included scientific databases such as 'Ebsco', 'IEEE Xplore', 'CiteSeerX Beta', 'Springer Link' and 'Google Scholar' for the same words. The selected keywords resulted in a total of 312 documents. We screen and eliminate the duplicates and irrelevant documents manually. After scanning the abstracts, we identify 25 documents as relevant. We then synthesize our findings and propose a decision framework for IT solution development. We define and describe the proposed framework in detail. Based on this framework, we propose a simulation model for prioritizing IT solution developments.

For an initial verification of the simulation model we conducted a case study in cooperation with a mid-sized German company. According to Benbasat, Goldstein and Mead (1987) case research in information research is clearly useful when a natural setting and contemporary events are in focus, which applies in this research. Participants of the case study were six professional-level employees: one CIO, one project manager, three software developers and one hardware developer, with between 5-15 years' work experience in the field. The case study participants were questioned to evaluate the IT solutions with respect to six main evaluation criteria, which we derive from the literature review (cf. section 5). Based on their evaluations, we were able to quantify the proposed model and simulate the priority ranking of IT solution developments. This priority ranking helps decision makers by determining the developing and integrating sequence of IT solutions.

6.3 Background: Theoretical Framework

In this section, we derive and describe the framework for IT solution developments. Since there were many points of congruence among the analyzed contributions, we synthesized them into five main steps: objectives setting, analysis, generating IT solutions, screening and evaluating IT solutions and prioritizing IT solutions (cf. Figure 17). As IT solution is not a standard product, but a solution that covers customer's needs, we suggest customer input integration in all steps.

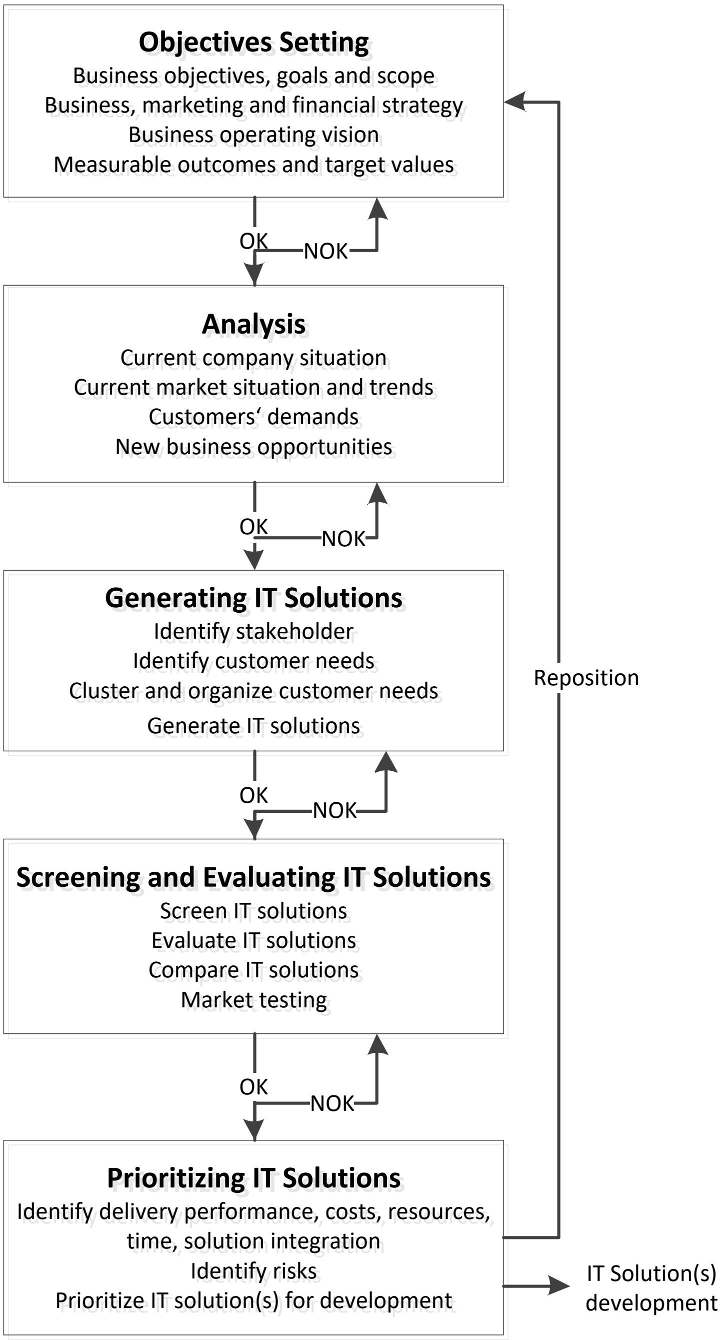

Figure 27. The decision framework for IT solution developments

6.3.1 Objective Settings

A number of authors from all contributions we analyzed suggest to start with setting business objectives, goals and scope, defining the business, marketing and financial control strategy (Alam & Perry, 2002; Arnold et al., 2005; Bowers, 1993; Cassidy, 2005; Daenzer, 2003; Harrison, 1996; Kelly & Storey, 2000; Lindemann, 2009; O'Brien & Smith, 1993; Scheuing & Johnson, 1989; Shekar, 2007). As Scheuing and Johnson (1989) have pointed out, many firms jump right into ideas generation, without first determining the desired business direction and operating vision. This is driven by an increased market competition, a sense of urgency, emerging trends in the market place such as higher customer expectation, or new technologies

(Scheuing & Johnson, 1989). To avoid vague statements regarding vision and strategy, organizations should define measurable outcomes and target values (Kaplan, Norton, & Barrows Jr., 2008). These activities define the "meaning and purpose" of the organization, formalize the organization's entering objectives and identify strategies for accomplishing these objectives (Camillus, 1986). We summarized all those activities in an "Objectives Setting Phase" as they relate to the goal whether the company targets the right markets and pursues IT solution development from a strategic point of view.

6.3.2 Analysis

Several researchers from all disciplines, we analyzed propose activities related to internal firm analysis (such as human resources, information technology, required infrastructure, or financial capital), external environment analysis (such as current market situation, current trends and needs, or user behavior, needs and attitudes) (Alam & Perry, 2002; Arnold et al., 2005; Bowers, 1993; Cassidy, 2005; Cowell, 1988; Daenzer, 2003; Elbanna & Child, 2007; Harrison, 1996; Hepperle et al., 2009; Kelly & Storey, 2000; Lindemann, 2009; Mintzberg, Rainsinghani, & Theoret, 1976; Pahl et al., 2007; Ritchie-Dunham, 2001; Scheuing & Johnson, 1989; Shekar, 2007), information gathering (e.g. from business benchmark, interviews, or surveys) (Witte, 1972) and analysis of business strength, weaknesses, opportunities and threats (Cassidy, 2005; Harrison, 1996). Additionally, Clark et al. (2009) suggest projection of the customer demand, which is a fundamental task to derive new IT solutions in the following phase. These activities provide information about the current business and market situation, current trends, customer demands, target markets and the competitive environment that help by exploring and identifying new business opportunities in the IT solution domain. Thus, we summarized all those activities in an "Analysis Phase" as they refer to insights of current business environment, industry trends, customer demand and competitive profiles.

6.3.3 Generating IT Solutions

Based on the findings and the knowledge available from previous phases about company opportunities, customer and market needs, a number of authors suggest to continue with activities such as searching and generating a set of solutions (Bowers, 1993; Cassidy, 2005; Cowell, 1988; Ference, 1970; Harrison, 1996; Hepperle et al., 2009; Kelly & Storey, 2000; Lindemann, 2009; Mintzberg, Rainsinghani, & Theoret, 1976; O'Brien & Smith, 1993; Pahl et al., 2007; Scheuing & Johnson, 1989; Shekar, 2007; Witte, 1972). Mintzberg, Rainsinghani and Theoret (1976) also propose activities such as searching for ready-made solutions and modification of ready-made solutions. Clark et al. (2009) propose ideas for the redesign of existing products that take into account the ability to harness developing technologies, materials and customer needs. These activities define the goal to come up with potential new solutions that satisfy the customers' individual business need. We summarized all those activities in a "Generating IT Solutions Phase" as they refer to new business opportunities identification that help to achieve the stated business goals and objectives.

6.3.4 Screening and Evaluating IT Solutions

Several authors from strategic management and new service development suggest to continue with activities such as solutions screening to separate the most promising from the less valuable solutions (Alam & Perry, 2002; Cassidy, 2005; Mintzberg, Rainsinghani, & Theoret, 1976; Scheuing & Johnson, 1989; Shekar, 2007), evaluation of solutions (Cassidy, 2005; Harrison, 1996; Mintzberg, Rainsinghani, & Theoret, 1976; O'Brien & Smith, 1993; Witte, 1972) and comparison of solutions (Ference, 1970; Harrison, 1996). Similarly, authors from new product development frequently mention activities regarding product ideas evaluation (Hepperle et al., 2009; Lindemann, 2009; Pahl et al., 2007). Some authors from new service development furthermore mention activities related to testing, pilot run and market testing before final decisions (Alam & Perry, 2002; Bowers, 1993; Scheuing & Johnson, 1989). These activities have several purposes, such as to obtain information about the effectiveness (Bowers, 1993) or to test mixed options (Bowers, 1993; Scheuing & Johnson, 1989). These activities define those few solutions or solution combinations that are worthy of additional attention. We summarized all those activities in a "Screening and Evaluating IT Solutions Phase" as they pertain to the satisfaction of customer's individual business needs and the organization's competitive advantage in the market.

6.3.5 Prioritizing IT Solutions

Many authors from all contributions we analyzed propose activities such as prioritizing solutions (Alam & Perry, 2002; Bowers, 1993; Cassidy, 2005; Ference, 1970; Harrison, 1996; Hepperle et al., 2009; Lindemann, 2009; Mintzberg, Rainsinghani, & Theoret, 1976; Pahl et al., 2007; Ritchie-Dunham, 2001; Scheuing & Johnson, 1989; Witte, 1972) and solutions comparison to running projects (Pahl et al., 2007). Delivery performance, components integration, time, cost, resources, risks and the business impact are detailed and reflected (Cassidy, 2005; Pahl et al., 2007; Tukker & Tischner, 2004). The IT solutions are prioritized and organized in order to effectively meet customers need (Pahl et al., 2007). Mintzberg, Rainsinghani and Theoret (1976) suggest also approval to commitment. These activities define the choice and the development sequence of IT solutions with e.g. significant business, customer and strategic value and provide basis for further company planning. We summarized all those activities in a „Prioritizing IT Solutions Phase" as they relate to the chain of activities that refer to developing of the new IT solutions.

6.4 Proposed System Dynamics Model in Combination with Fuzzy Logic

Based on the framework for IT solution developments, which we derive from literature in the previous section, we propose a simulation model for prioritizing IT solution developments. We divide the model into two main modules: Evaluating IT solutions and prioritizing IT solutions.

Both modules make use of the consistent fuzzy preference relation, proposed by Herrera-Viedma et al. (2004), since it only requires *n-1* judgments from a set of *n* IT solutions. The consistent fuzzy preference relation is used to improve decision making consistency and effectiveness (Wang & Lin, 2009). According to several researchers (cf. Herrera-Viedma et al., 2004), fuzzy preference relation is the most common representation of information used in decision making when we want to aggregate experts' preferences into group preferences.

Successful applications of this method can be found in several research contributions (e.g. in Wang & Lin, 2009).

6.4.1 Module: Evaluating IT Solutions

IT solution providers usually offer different combinations of product and service components. They have to design, modify and select products and services that work well with each other as well as meet customer's business needs (Tuli, Kohli, & Bharadwaj, 2007). These component combinations must be adapted and integrated to each other as well as to the customer's business processes. Therefore, decision maker must consider the company's strategy, company's resources and technological opportunities, to evaluate and offer the right IT solution, which covers customers' business needs.

At this level, the needed information for the evaluation is numerous. Therefore, decision makers have to first determine the main evaluation criteria as well as their weight; since, the main evaluation criteria do not have an apparent superiority on each other. To obtain the weights of the evaluation criteria, we propose to use subjective judgments on linguistic terms such as "very important" or "rather important". For this step, we integrate an user interface in our simulation model. Thus, the model implementation and calculation remain hidden for the decision makers. The user interface contains structure that allows decision makers to modify the set of evaluation criteria; i.e. they can add or remove evaluation criteria if required. However, to get the group preferences the number of criteria must be same for all evaluators. Afterwards, individual judgments are integrated together in order to get the final weights of evaluation criteria, which are needed for the IT solutions prioritizing.

Figure 28 shows the model overview for the Evaluation of IT solution criteria.

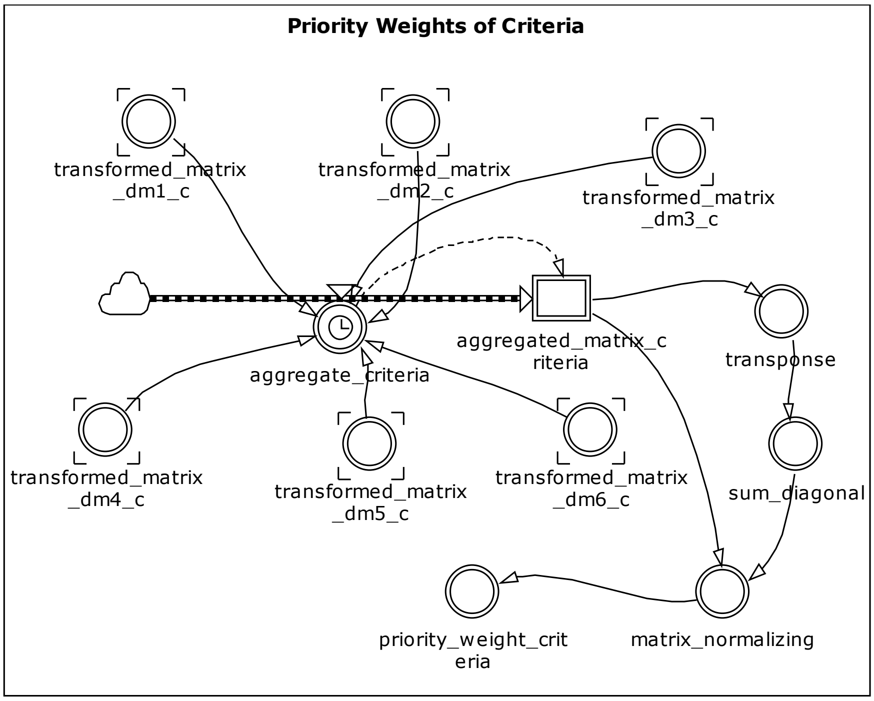

Figure 28. Model overview for evaluation of IT solution criteria

The variables “transformed_matrix_dm*_c” are arrays containing the fuzzy numbers of the evaluated criteria for each decision maker. These variables are connected to the flow rate variable “aggregate_criteria” which pooled the evaluators’ judgments for the considered criteria together in a matrix form. The results of the evaluators’ judgments are then transferred into an aggregated matrix “aggregated_matrix_criteria”. Since, we could get also negative numbers in the aggregated matrix, we need to transform and normalize the matrix. These steps are performed in the variables “transponse”, which swaps columns for rows in the matrix and “sum_diagonal”, which calculates the sum of assessment values of *m* decision makers and serves together with the variable “aggregate_criteria” as inputs to normalize the matrix. After normalizing the matrix, we can estimate the final weights of evaluation criteria. This step is performed in the variable “priority_weight_criteria”.

6.4.2 Module: Prioritizing IT Solutions

Since, IT solution consists of standard and individual components, it is necessary to determine which components are standard and which are individual. Standard components are products or services that can be purchased on the market. Individual components require the adaption of standard components or the development of new product or service components. Both individual and standard components should be developed or modified jointly to guarantee ease of integration. However, due to different manufacturing periods and different lifecycles of single parts, this can be a challenging task for IT solution providers (Berkovich et al., 2009). Thus, the priority and sequence of IT solution developments is crucial for the successful implementation and deployment into customer’s business environment.

In order to realize such prioritization, decision makers have to weigh the developments of new IT solutions by taking the apparent evaluation criteria into account. Similar, to the previous module, decision makers evaluate a set of IT solutions in the user interface with respect to each evaluated criterion based on their subjective judgments with the help of linguistic terms, such as “very high”, “high”, or “fair”. In a fuzzy context, where decision makers express their judgments using fuzzy preference relations, the transitivity rule is used to characterize the consistency; i.e. if IT solution s_i is preferred to IT solution s_j and this one to s_k then IT solution s_i should be preferred to s_k. After obtaining the individual preferences for the set of IT solution developments we can determine the priority ranking of their developments. We therefore multiply the preference ratings of IT solution developments with the weight of considered criteria to get the final prioritizing of IT solution developments.

Figure 29 shows the model overview for the prioritizing of IT solutions.

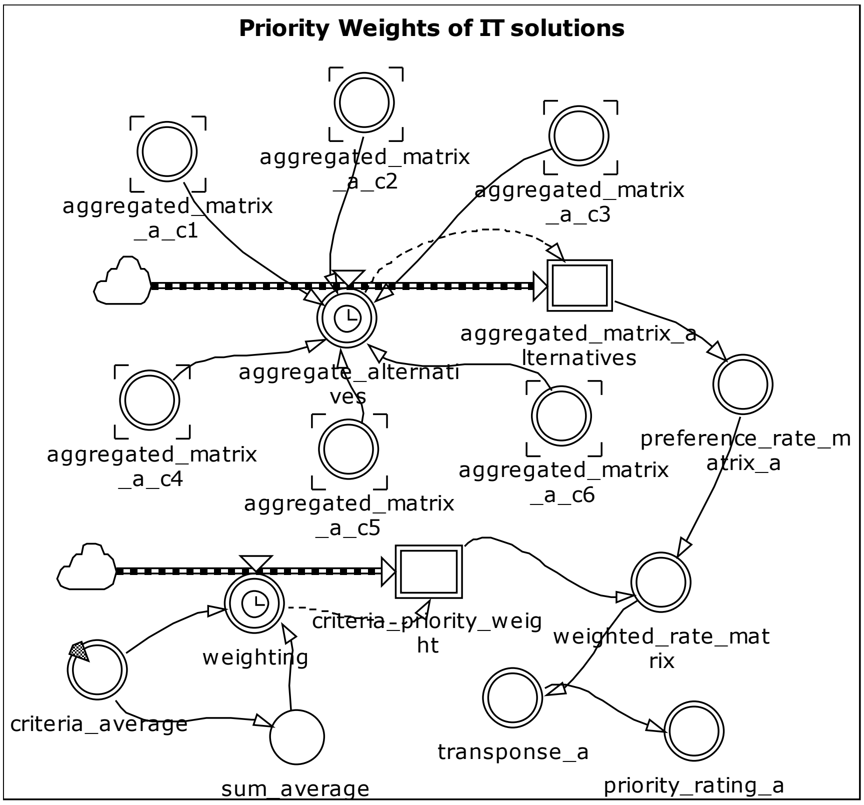

Figure 29. Model overview for prioritizing of IT solution developments

The variables "aggregated_matrix_a_c*" are arrays containing the fuzzy numbers of evaluated IT solutions for each decision maker. These variables are connected to the flow rate variable "aggregated_alternatives" which integrates the evaluators' judgments for the IT solution preferences. The aggregated matrix of all evaluators' judgments is then established by using the input of the flow rate "aggregate_alternatives". To get the priority weight of IT solutions, we need to multiply them by the criteria weights, which we calculated in the previous module. The variable "criteria_average" represents the priority weight of each evaluation criterion and serves as an input for the "weighting" flow rate variable, where we calculate the average priority of each criterion. The flow rate variable serves as an input for the "criteria_priority_weight", which flows together with "preference_rate_matrix_a" into the variable "weighted_rate_matrix", where we compute the priority ranking of IT solution developments, which we then transpose in order to get the final prioritizing of IT solution developments in the variable "priority_rating_a".

Since, IT solution providers face dynamic concerns, such as changing requirements or technology improvements, the simulation makes it easy to run a number of "what-if" scenarios, in order to react promptly on such dynamic challenges.

6.5 Case Study

To evaluate the applicability of the proposed model, we apply it by a medium sized German company for IT solution development. The decision making team consists of six decision makers: one CIO, one project manager, three software developers and one hardware developer, with between 5-15 years' work experience in the field. In the case study we treat all decision makers as equal and do not consider the priority weights of their judgments.

Based on the decision framework, the company developed following IT solutions that need to be prioritized for the development: (1) File service: restructuring of the entire file system from Linux to Windows, (2) Collaboration platform: developing a new communication platform based on Microsoft Exchange Server, (3) Print service: developing and implementation of a centralized and decentralized print concept, (4) Web service: managing and converting the individual business unit content into web-application content, (5) Customer relationship management: for planning and managing new customer services and (6) Marketing information system: for planning, analyzing and evaluating new market opportunities and sales activities.

6.5.1 Identifying Evaluation Criteria

To evaluate the IT solution developments, we need to derive the evaluation criteria first. The evaluation criteria are fundamental to IT solution developments, since they are specific to each IT solution provider, as they vary according to their and customer's needs.

Hart (1993) argues that for alternatives evaluation both financial and nonfinancial success measures can be used. Hauschildt (1991) suggests to measure both technical and economic perspective. Cooper and Kleinschmidt (1987) empirically identify three performance aspects for solutions evaluating, which they term as "financial performance" (financial success of a new product), "market impact" (product in its market places) and "opportunity window" (new opportunities). Markowitz (1952) suggests to start with the evaluation of benefits and risks. Buyukozkan and Feyzioglu (2004) furthermore divide the benefits into tangible benefits, such as profitability and efficiency, intangible benefits, such as strategic value and business impact, tangible risks, such as financial and technical risks and unsystematic risks such as managerial and personnel.

Based on synthesis of the literature review, we summarize the evaluation criteria as follows: profitability (C1), strategic value (C2), business impact (C3), financial risks (C4), strategic risks (C5) and technical risks (C6).

6.5.2 Determining the Importance Weight of Evaluation Criteria

First step in this case study is to determine the importance weights of each criterion by comparing the neighboring criteria to each another. To perform these pairwise comparisons for six evaluation criteria, we invited the decision makers to express their subjective judgments with the help of linguistic terms as listed in Table 18. We use a 1-9 ratio scale, whereby the linguistic term "unimportant" represented with quantitative scale 1 indicates indifference between criterion 1 and criterion 2 and the linguistic term "very important" with quantitative scale 9 indicates that criterion 1 is absolutely preferred to criterion 2.

Definition	Quantitative Scale
Very Important (VI)	9
Rather Important (RI)	7
Important (I)	5
Less Important (LI)	3
Unimportant (U)	1
Intermediate values used to express compromise (C)	2,4,6,8

Table 18. Linguistic terms for priority weights of criteria

The decision makers systematically evaluate the various evaluation criteria by comparing them to one another in pairs for a set of *n-1* preference values. In making comparisons, the decision makers use their judgments about the adjoining criteria' relative meaning and importance. It is the essence of the fuzzy preference relation that evaluator's judgments and not only the underlying information, can be used in performing the evaluations. In Table 2, we list the importance of each neighboring criteria based on decision makers' judgment. For example, DM_5 denotes criterion 1 *"rather important"* as criterion 2 and criterion 4 as "*very important"* in comparison to criterion 3. This reverse direction of judgments for criterion 3 and 4 is in the table represented with *"I"* and signifies *"inverse"* judgment (cf. Table 19).

	DM_1	DM_2	DM_3	DM_4	DM_5	DM_6	
C_1	C	VI	C	RI	RI	IRI	C_2
C_2	I	I	I	II	I	VI	C_3
C_3	IRI	C	IVI	IRI	IVI	I	C_4
C_4	II	RI	IRI	RI	ILI	II	C_5
C_5	RI	II	I	RI	II	I	C_6

Table 19. Evaluation results for each criteria assessed by decision makers

After collecting all decision makers' subjective opinions, we can establish the preference matrices among all six criteria for each decision maker. Their evaluations are converted into corresponding numerical values in the interval [1/9, 9] and then in the range of [0, 1]. If the preference matrix contains any values, which are not included in the interval [0,1], then a transformation function is required to preserve the reciprocity and additive transitivity.

After obtaining the preference matrix for each decision maker, we can pool their judgments together in order to obtain the aggregated group preference of priority weights for each criterion. Figure 30 shows the aggregated values, which represents the whole evaluation range of the decision makers.

Priority Weights of Evaluation Criteria

	C1	C2	C3	C4	C5	C6	Total	Avg
C1	0,207	0,20	0,193	0,199	0,204	0,197	1,2	**0,20**
C2	0,17	0,169	0,169	0,169	0,169	0,169	1,015	**0,169**
C3	0,115	0,124	0,133	0,125	0,119	0,128	0,744	**0,124**
C4	0,167	0,167	0,167	0,167	0,167	0,167	1,002	**0,167**
C5	0,193	0,188	0,184	0,188	0,191	0,186	1,13	**0,188**
C6	0,149	0,152	0,155	0,152	0,15	0,153	0,911	**0,152**

Figure 30. Priority weights of evaluation criteria

Based on these aggregated group preference values, we can calculate the final ranking and weighting of considered criteria. Thus, we use the average method; i.e. we sum the values in rows for each criterion and divide them by the number of decision makers. For example, the average priority value of criterion 1 is obtained as follows: (0.207 + 0.2 + 0.193 + 0.199 + 0.204 + 0.197) / 6. The simulation model performs these calculations and the ranking of criteria weights can be summarized as follows: profitability (0.2), strategic risks (0.188), strategic value (0.169), financial risks (0.167), technical risks (0.152) and business impact (0.124). The priority ranking represents the combined opinions of the decision makers about the importance of each evaluation criterion.

The results show that the criterion profitability is considered as one of the most important criterion followed by the strategic risks criterion. The criteria strategic value and financial risk show only minor difference in their weightings. The criterion business impact is evaluated as least important criterion.

The weights of evaluation serve as an input for prioritizing the IT solution developments.

6.5.3 Prioritizing

After obtaining the weighting and ranking of evaluation criteria, the next step in this case study is to determine the preference rating of six IT solution developments with respect to the considered criteria. The six decision makers are furthermore asked to express their subjective judgments using the linguistic terms: very high (VH) with value 5, high (H) with value 3, fair (F) with value 1 and intermediate values used to express compromise (C) with values 2 and 4. They evaluate the importance for each two adjoining IT solutions for a set of *n-1* preference values with respect to the evaluation criteria.

Table 20 lists the decision makers' pairwise evaluations. For the brevity purpose, we list only the evaluations for the first two criteria.

		DM_1	DM_2	DM_3	DM_4	DM_5	DM_6
	S_1	IVH	IH	IVH	IVH	IVH	IH
	S_2	H	H	H	H	H	IVH
C_1	S_3	IVH	IH	IH	H	IVH	IVH
	S_4	IH	VH	IVH	C	VH	IH
	S_5	H	IVH	H	F	F	IF
	S_1	IVH	IVH	IVH	IH	IH	F
	S_2	VH	VH	VH	C	VH	H
C_2	S_3	C	IH	F	H	IH	F
	S_4	H	VH	C	IH	H	F
	S_5	C	IVH	H	H	H	VH

Table 20. Preference ratings for IT solution developments

After collecting the decision makers' evaluation for each IT solution with respect to each considered criterion, we convert the linguistic terms into the corresponding numerical numbers in the interval [1/5, 5] and then in the range of [0, 1]. We make again the use of transformation function, if the converted numbers are not included in the interval [0, 1]. After we obtain the pairwise comparison matrices from six decision makers, we can integrate their evaluations together, in order to obtain the group average rating for each IT solution.

Based on these group preferences, we can simulate the preferred values of IT solution developments. Thus, we multiply the priority weights of the evaluation criteria with the group preferences of IT solutions. Take IT solution S_1 as an example, the preferred weight for the S_1 is obtain as,

S_1 = (0.2 * 0.103) + (0.169 * 0.176) + (0.124 * 0.199) + (0.167 * 0.114) + (0.188 * 0.223) + (0.152 * 0.22) = 0.169

Figure 31 presents the final preferred weights of IT solution developments with respect to evaluation criteria. Based on these preferred values, we can determine the developing and integrating sequence of IT solutions.

Priority Weights of IT solutions

	Weight	S1	S2	S3	S4	S5	S6
C1	0,20	0,103	0,184	0,132	0,187	0,193	0,202
C2	0,169	0,176	0,257	0,165	0,169	0,138	0,096
C3	0,124	0,199	0,16	0,157	0,18	0,166	0,138
C4	0,167	0,114	0,194	0,126	0,184	0,172	0,209
C5	0,188	0,223	0,194	0,191	0,158	0,14	0,093
C6	0,152	0,22	0,198	0,18	0,152	0,161	0,089
Total		**0,169**	**0,199**	**0,158**	**0,172**	**0,162**	**0,14**

Figure 31. Priority weights of IT solutions with respect to evaluation criteria

Furthermore, based on the preference weighs, we can summarize the ranking of IT solution developments as follows: collaboration platform (0.199), web service (0.172), file service (0.169), customer relationship management (0.162), print service (0.158) and marketing information system (0.14).

After presenting and discussing the results with the case study partner, they are developing and integrating the IT solutions according to the simulation results. Based on the priority ranking, they furthermore decided to classify the IT solution developments into dominance and non-dominance set. The dominance set consists of: collaboration platform, web service, file service and customer relationship management. The non-dominance set is: print service and marketing information system. The non-dominance set of IT solutions is postponed to undefined time, as these IT solutions are prioritized as less important.

6.6 Discussion

The results of this research show that application of system dynamics to prioritizing IT solution developments can be combined with applications based on fuzzy logic. System dynamics is a suitable method for analyzing complex systems, such as the development process of IT solutions and fuzzy logic is a suitable method for decisions, where a source of vagueness is involved, which also apply in IT solution development processes. Moreover, the priority ranking of IT solution developments help by analyzing in which sequence the IT solutions should be developed and integrated into customers' business processes and IT infrastructure.

In this research, we also found, that through combination of these two promising approaches, we can overcome some limitations these approaches cope with. System dynamics models cope with model validity; i.e. no single test exists for system dynamics model validation (Forrester & Senge, 1980). By applying fuzzy logic to system dynamics, we could increase the model confidence. Fuzzy logic, on the other side requires extensive calculation, which leads to avoid using it. With the proposed simulation model, we were able to hide the extensive fuzzy logic computation.

However, this research is not without its limitations. In this paper, we only investigate the evaluating and prioritizing of IT solution developments. Thus, in future research, we need to extend our model to also account for other dynamic process dimensions, such as financial (e.g. cash flow, or revenues), or company analysis (e.g. technological, or resource allocation). We also need to apply the simulation model in different case studies to ensure the general applicability of the proposed simulation model.

6.7 Conclusion

We first derived a decision framework for IT solution developments from a wide range of related literature, such as new product, new service development and decision making. We found that IT solutions display special characteristics that confront decision makers during the IT solution developments. We therefore, suggest a simulation model combining system dynamics and fuzzy logic with respect to the special characteristics of IT solutions. The proposed model based on the derived framework and supports decision makers by prioritizing IT solution developments. We then show the model applicability in a case study by a mid-sized German company. Six decision makers were involved in this case study. They are professional-level employees, such as CIO, project manager, software and hardware developer, with work experience of 5-15 years. They evaluated six IT solutions regarding to the evaluation criteria. The simulation results help by determining the priority rating of IT solution developments.

This contribution is intended to fill the gap where an integrated approach for decision makers that face decisions in complex IT solution developments, is lacking.

Practitioners will find the decision framework useful by generating new IT solutions and the proposed simulation model by managing IT solutions developments, as well as for analyzing different prioritizing scenarios virtually before transferring them into the real world.

Researchers can use the proposed model as a starting point for analyzing and understanding the IT solution developments, or for testing different types of hypothesis and deriving recommendations for further actions.

In future work the authors will concentrate on extending the proposed simulation model to also account for other process steps of the new IT solution development, such as market analysis, company’s resources, or the financial dimension.

7 A System Dynamics Model for Business Process Change Projects[10]

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Table 21. Fact sheet publication P7

Abstract. At present, companies are confronted with a rapidly changing environment that is characterized by high market pressure and technological development, which results in shorter delivery times, lower development costs and increasingly complex business processes. Companies must be continuously prepared to adapt to changes to remain competitive and profitable. Thus, many companies are undergoing significant business process change (BPC) to increase business process flexibility and enhance their performance. Various researchers have advanced the domain of BPC over the last twenty years, proposing several managerial concepts, principles and guidelines for BPC. However, many BPC projects still fail. BPC is seen as a complex endeavor and its decisions are shaped by many dynamic and interacting factors that are difficult to predict. Thus, this paper proposes a system dynamics simulation model that conveys the complex relationships between important constructs in BPC. The resulting model is based on results compiled from 130 BPC case studies. BPC researchers can use the proposed model as a starting point for analyzing and understanding BPC decisions under different policy changes. Practitioners will obtain a ready-to-use simulation model to make various BPC decisions.

7.1 Introduction

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Today's dynamic and unpredictable business environment, shrinking product lifecycles and rapidly changing customer requirements, as well as the effects of recent financial crises, are only some of the main reasons why companies must be continuously prepared to face changes. Otherwise, competitive advantages might be lost to more flexible or more innovative companies over time. These market conditions have led to an increasing research interest in improving organizational business processes to increase flexibility and enhance performance (Trkman, 2010). Business process change (BPC) has been one method for organizations to adapt to a rapidly changing environment.

BPC projects present complex phenomena and are often fraught with uncertainties, frequent delays, or even failures. Because BPC is a holistic approach, it bears many organizational, technological, economic and social risks and even today, approximately 60% to 80% of BPC projects have been unsuccessful (Cao, Clarke, & Lehaney, 2001; Kliem, 2000; Strebel, 1996; Trkman, 2010). A key facilitator for the success of BPC projects is to ensure organizations' ability to understand and cope with the complex organizational and economic tasks introduced by these projects.

Simulation models, such as system dynamics (SD) models, might be helpful in such complex initiatives; they provide insights into feedback processes and lead to a better understanding of the dynamic behavior of the studied phenomena (Flood & Jackson, 1991). They provide a graphical display that can be interactively edited and animated to demonstrate the dynamics of different decisions (Baguma & Ssewanyana, 2008). SD has proven to be an effective tool in managing (e.g., representing, modeling and comprehending) the complexities of multiple requirement domains that involve complex structures (e.g., feedback loops, delays and uncertainties; (Forrester, 1961, 1985, 1992; Senge, 2006; Spector & Davidsen, 1997). Other researchers (Madachy, 2008; Vergidis, Tiwari, & Majeed, 2006; Xirogiannis & Glykas, 2004) have argued that participants will be able to grasp the important parameters and complex feedback loops more easily through the use of SD.

This study proposes an SD model for BPC projects that captures the main BPC impact factors and the relationships between them. By eliciting impact factors and their mutual relationships from 130 BPC case studies, we aim to increase the transparency of causal links and effects within these projects, thereby enhancing practitioners' abilities to anticipate and cope with these phenomena.

The theoretical and practical contributions of this research are as follows. By introducing an approach to the identification of factors that influence the outcome of BPC projects and the relationships among these factors, we assist both practitioners and researchers in improving their understanding of the complex dynamics involved in BPC projects. This understanding is enhanced by a proposed SD model that allows the impact of certain factors to be tangibly examined and various decisions to be compared without time and cost pressures or other resource constraints.

The remainder of this paper is organized as follows. In section 7.2, we provide an overview of BPC and review the application of SD in BPC and adjacent areas. In section 7.3, we describe the process and problem statement and we explain our SD simulation model. In section 7.4, we demonstrate the use of the SD model by simulating various decisions. We discuss our results and limitations in section 7.5 and present our conclusions in section 7.6.

7.2 Theoretical Foundation

The following section introduces the theoretical background, which consists of BPC and the application of SD in BPC and adjacent areas. First, the BPC subchapter contains a definition and discusses the origin of the concept and its components. Because BPC combines continuous and radical approaches in one management concept (Grover & Markus, 2008), two prominent approaches for each section; i.e., BPR as a radical approach and TQM as a continuous approach, are briefly discussed. Furthermore, the concept of BPR is explained and frameworks for success are introduced. The second subchapter provides an overview of the application areas of SD. The publications presented in this section contain the research areas of change management, supply chain management, project management and BPC. A brief summary of the simulation objectives and targets as well as interesting results in these application areas is presented.

7.2.1 Business Process Change

BPC was initially proposed by Kettinger and Grover (1995) and the concept was subsequently enhanced by Grover and Kettinger (1997) and Kettinger, Teng and Guha (1997). BPC is a management approach that involves any type of change and is defined as a “strategy-driven organizational initiative to (re)design business processes to achieve significant (breakthrough) improvements in performance (quality, responsiveness, cost, flexibility, satisfaction, shareholder value and other critical process measures) through changes in the relationship between management, information, technology, organizational structure and people” (Kettinger & Grover, 1995). Because these initiatives can differ in their scope due to the degree of change that is fostered in each organization, the definition of BPC involves the integration of continuous/evolutionary and radical/revolutionary management approaches, such as total quality management (TQM) and business process reengineering (Grover, Kettinger, & Teng, 2000; Grover & Markus, 2008; Sarker, Sarker, & Sidorova, 2006), as presented in Figure 32.

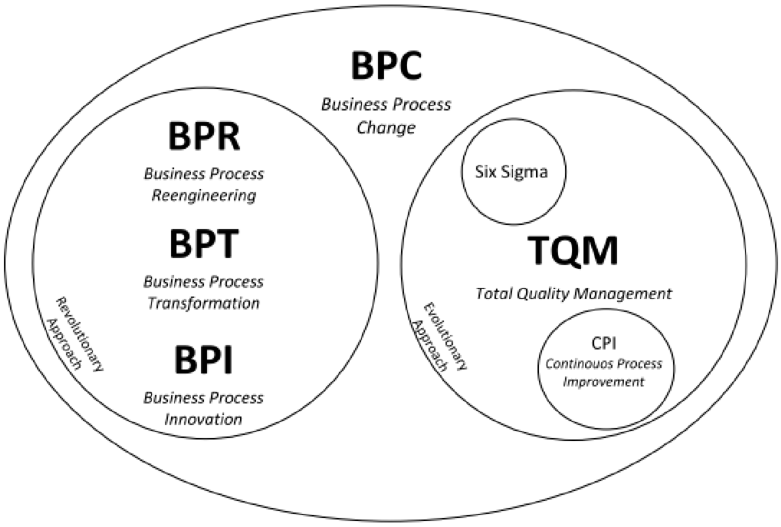

Figure 32. Central elements of BPC

To highlight the fact that BPC is an integration of two independent types of management concepts, one type of each category is briefly described in this section; i.e., BPR for radical and TQM for evolutionary management concepts.

BPR is defined as fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary performance measures, such as cost, quality and speed (Hammer & Champy, 1993). Revolutionary change approaches are based on the assumption that change requires a reinvention of the company; thus, it is considered rather radical (Hammer & Champy, 1993). Reengineering implies starting with a blank sheet approach (Davenport & Stoddard, 1994). Following Kristekova et al. (2012a), aside from this BPR, business process redesign, business process innovation (BPI) and business process transformation (BPT) will be used as synonyms in this paper. Grover and Markus (2008) analyzed the difference in these concepts' wordings and concluded that they are essentially the same concept.

In contrast, TQM is an evolutionary process of continuously improving an organization's business processes (Crosby, 1979; Deming, 1981, 1982, 1986; Ishikawa, 1976; Juran, 1974; Suarez, 1992). Dale (1994) defines TQM as "the mutual co-operation in an organization and associated business processes to produce value-for-money products and services which meet and hopefully exceed the needs and expectations of customers." TQM can be regarded as both a philosophy and a set of guiding management principles for an organization to improve quality (Dale, 1994). According to Juran & Gryna (1988), quality is defined as "fitness for use" and thus includes two aspects: product features and freedom of deficiencies. Quality improvements involve both reducing the costs of poor process quality and improving performance in these processes (Suarez, 1992, p. 8). For company-wide quality management, organizations must focus on the following three basis processes: quality control (to gain conformance), quality improvement (by specific projects) and managerial and technical breakthroughs (quantum leaps in performance; (Juran, 1974), also called the Juran Trilogy (Powell, 1995). These breakthroughs can lead to "improving quality to unprecedented levels" through the attainment of quality leadership, solutions to an excessive number of field problems and improvement in the organization's public image (Juran, 1992).

BPC is more generally understood as a shift toward processes to drift away from the negatively connoted management approaches, such as BPR, that emerged in the 1990s after quality management approaches lost their momentum and could not achieve the promised results (Grover, Kettinger, & Teng, 2000). Today, even Michael Hammer, who first coined the term BPR, is convinced that a structured process analysis is preferred to a radical approach (Grover, Kettinger, & Teng, 2000). Grover, Kettinger and Teng (2000) found the BPR concept was originally developed by powerful management consultants who intended to sell their expensive proprietary guidance. When asked whether BPC is the same as BPR, Grover, Kettinger and Teng (2000) answered in an interview "yes and no". BPC represents a more realistic perspective, is strategy-driven and does not only intend to cut costs. According to Grover, Kettinger and Teng (2000), there was a necessity to "broaden the business change tent to accommodate radical business objectives, incremental implementations and both top-down and bottom-up driven process change". The revolutionary and evolutionary approaches that are integrated in BPC share common goals, such as process improvements; thus, they are often used complementarily in organizations (Grover & Markus, 2008). In fact, many projects are labeled as radical even though they have a low probability of achieving dramatic improvements (Margherita & Petti, 2010).

However, based on the increased research interest in BPC, particularly in the second half of the 1990s, many frameworks for the success factors of BPC projects have been published in the literature (see Grover, 1999; Guha et al., 1997; Jurisch, Cuno, et al., 2012; Jurisch, Wolf, & Krcmar, 2013; Kettinger & Grover, 1995; Melville, Kraemer, & Gurbaxani, 2004). Jurisch et al. (2012) conducted an extensive study on the success factors of BPC projects and argue that there are two predominant streams in literature; i.e., an organizational change perspective (Grover, 1999; Guha et al., 1997; Kettinger & Grover, 1995) and a process-oriented perspective, which is more concerned with analyzing the effects of IT investments on business process performance (Melville, Kraemer, & Gurbaxani, 2004). The first model developed to conduct BPC projects in organizations was first introduced in 1995 by Kettinger and Grover and later presented in their MISQ article (Kettinger, Teng, & Guha, 1997). The model consists of environmental factors that lead to a strategy that affects information and technology, management, structure, people, products, services and performance, which are the basis for the first theoretical framework of BPC. The model is based on the assumption that "any significant process change requires a strategic initiative where top managers act as leaders in defining and communicating a vision of change" and that the organizational environment should be the basis on which the implementation of process and change management practices is built (Guha et al., 1997). Finally, enhanced business processes should lead to customer success, which creates quantifiable success (Kettinger, Teng, & Guha, 1997). The framework of Kettinger and Grover (1995) consists of categories that contain 25 success factors in total. The importance of incorporating learning capacity, network balancing, change management and process management as success factor categories is introduced in their framework (Kettinger & Grover, 1995). Two years later, Guha et al. (1997) highlight the large effect of effective change management on the overall success of a BPC project. In fact, the framework of success factors developed by Kettinger and Grover (1995) was used many times in the BPC literature; i.e., to explore the antecedents of the connection between BPC and organizational performance (Guha et al., 1997) or to study the methodologies, techniques and tools of BPC (Kettinger, Teng, & Guha, 1997). The next framework, which includes 14 success factors of five categories, marks a milestone in the literature about management approaches to facilitate change (Grover, 1999). Grover and colleagues were convinced from the beginning of their research that aside from its high relevance for organizations operating in highly changing environments, BPR is also simply a buzzword that was developed and evolved by consultants; thus, they suggested viewing process change in a more realistic way, which meant to incorporate continuous change approaches, such as TQM (Grover, Kettinger, & Teng, 2000). However, the role of IT is of key importance in today's change projects (Grover, 1999) and IT is not fully integrated in the framework of Kettinger and Grover (1995). Although Kettinger and Grover (1995) consider the success factors connected to information and technology, e.g., data and information and information technology, as helpful when conducting a BPC project, Grover (1999) was the first to identify technology management. However, his study on technology management did not find a correlation between technology management and project performance and he advised that change management— not technology management—should be the preferred category of consideration (Grover, 1999). The second stream of frameworks for the success factors of BPC projects integrates the importance of IT in BPC projects. Melville, Kraemer and Gurbaxani (2004) developed the most recognized one, which includes IT resources, such as technical infrastructure and business applications and the technical and managerial skills employees need to operate them. Industry specifics; i.e., the way IT is applied to generate business value, the resources of trading partners in their value network and country-specific success factors that affect IT, such education and culture, are also considered (Melville, Kraemer, & Gurbaxani, 2004). As a synthesis between evolutionary and revolutionary management approaches and by highlighting the enabling effect of information systems on corporate strategy, Jurisch et al. (2012) created an integrative model of IT-Enabled BPC because until then, none of the proposed success factor models had been established as standard in the literature. Forty success factors for BPC projects in the framework of Jurisch et al. (2013) have been derived based on this model. Volatility was also studied as an additional category in the prior frameworks. In detail, the negative effects of executive sponsor volatility, competitive environment volatility, strategy volatility and political/governmental volatility were studied in 128 case studies of BPC projects (Jurisch et al., 2013).

7.2.2 Adoption of System Dynamics in BPC and Other Domains

SD has been applied in various contexts due to these numerous advantages of simulation techniques. Table 22 shows an overview of the identified SD publications in BPC and adjacent research areas.

Application area	Sources
Change management	(Cooper & Reichelt, 2004; Eden, Williams, & Ackermann, 1998; Howick & Eden, 2001; Howick, 2003)
Supply chain management	Akkermans & Dellaert (2005); Anderson et al. (2005); Spengler & Schroeter (2003)
Project management	(Lyneis, Cooper, & Els, 2001; Park & Pena-Mora, 2003; Skoldberg, 1994; Taylor et al., 2011)
BPC	(Ashayeri, Keij, & Broeker, 1998; Baguma & Ssewanyana, 2008; Kristekova et al., 2012; van Ackere, Larsen, & Morecroft, 1993)

Table 22. Application areas of SD publications

The target of applying SD to change management practices is primarily to study the effects of disruption and delay (D&D) (Cooper & Reichelt, 2004; Eden, Williams, & Ackermann, 1998; Howick & Eden, 2001; Howick, 2003). Cooper and Reichelt (2004) investigate the effects of D&D, such as added expenditures, scope and delays, in terms of cause-effect modeling. Eden et al. (1998) focus on the learning curve in development projects, particularly when clients change requirements and the effect of modifications, new work and increased complexity. As a result, guidelines for project managers for future development projects are developed (Eden et al., 1998). Similarly, Howick and Eden (2001) explore the effect of D&D in large-scale projects when early delivery is demanded by customers after the project has already started. However, Howick (2003) also discusses the theoretical requirements of applying SD for modeling D&D for litigation. Four criteria and challenges associated with the use of SD are identified: modeling exogenous events and their outcome as D&D, modeling the paths of argument from an action to an eventual outcome, quantifying the outcome of D&D and replicating the reality in a convincing manner for the model's entire audience (Howick, 2003). According to Howick (2003), SD is suitable for change management simulation because it provides a structural model (vs. a black box model) and integrates a feedback view by capturing "the cause and effect relationships within a system, particularly focusing on any feedback loops created by relationships".

In the supply chain management literature, SD is primarily used to simulate capacity management to anticipate the bullwhip effect (Akkermans & Dellaert, 2005; Anderson Jr, Morrice, & Lundeen, 2005). Anderson et al. (2005) developed a dynamic capacity management model for service and manufacturing supply chains with varying demand and information sharing among the supply chains' stages. Their SD simulation model indicated that lead-time reduction may intensify the bullwhip effect if it is not harmonized with capacity adjustments. The SD simulation model helped them to find an outperforming asymmetric policy by holding the highest volume of system backlog at the stage most adjacent to the customer demand point. Spengler & Schroeter (2003) developed an integrated production and recovery system to manage the supply chain of spare-parts demands for electronic equipment. Therefore, a SD model was developed to determine the extent to which the dynamic management of spare parts could reduce costs. The model developed by Akkermans & Dellaert (2005) perceived delays and the authors consider SD to be the "perfect candidate to analyze the more complex settings of today's supply chains and supply chain networks."

Simulation is primarily used in the project management field to enhance project performance and/or reduce rework (Lyneis, Cooper, & Els, 2001; Park & Pena-Mora, 2003; Taylor & Ford, 2006). Lyneis, Cooper and Els (2001) developed a SD simulation model to support the project management stages, including planning, bidding, measurement determination, the identification and evaluation of risk and organizational learning, for an Air Force project to build a defense system. Based on the simulation, the project was successfully completed six months ahead of schedule. Another application was the project management for the construction of 27 bridges in the U.S. to avoid rework due to changes in the design and specification of downstream tasks (Park & Pena-Mora, 2003). A dynamic project simulation model was used to reduce schedule delays and cost overruns. Through the simulation of different scenarios, non-value-adding change iterations were decreased, leading to a 35% reduction of the project schedule and a 30% cost reduction compared to the base model (Park & Pena-Mora, 2003). Taylor & Ford (2006) illustrated that even an elementary feedback loop may cause complex tipping dynamics that could lead to project failure. By applying robustness to project design, they showed that control loop dominance can enhance project performance in a single project setting.

Several authors clearly demonstrate the suitability of SD simulation modeling in the context of BPC projects (Ashayeri, Keij, & Broeker, 1998; Baguma & Ssewanyana, 2008; Burgess, 1998; Kristekova et al., 2012; van Ackere, Larsen, & Morecroft, 1993). The publications in this area explore the link between SD and BPC and are focused primarily on exploring which components can achieve the highest improvements through simulation (Ashayeri, Keij, & Broeker, 1998; Baguma & Ssewanyana, 2008; Kristekova et al., 2012). Kristekova et al. (2012) analyzed the SAP sales process and developed and tested several management policies, such as the reduction of rework, by accelerating training for new employees or shortening the approval process. Van Ackere, Larsen and Morecroft (1993) studied the connection between SD simulation and BPR by using the classic logistics system called the "beer game", which represents a multi-stage production and distribution system. The advantage of this early SD application is the graphic illustration of core business processes and the interactions within the organization. Ashayeri et al. (1998) designed a conceptual framework to restructure processes with added value for the customer. This framework combines internal and external criteria; i.e., criteria important for the customer and criteria for internal performance measurement and allows for simulations that determine which business unit yields the largest enhancements in the BPC project. Furthermore, Ashayeri et al. (1998) combined SD with the analytical hierarchy process (AHP) to allow managers to divide problems into atomic sub-problems in a top-down manner. Burgess (1998) suggested a simulation model for an organization that concentrates on capabilities that are competitive in terms of quality, cost, time and flexibility. The simulation model that is primarily rooted in the OM literature shows that most benefits for the organization arise from cost reduction because of the BPC project. Other authors (Baguma & Ssewanyana, 2008) studied the effect of IT infrastructure on BPC projects and collected data from five commercial banks to test the proposed simulation model. By testing different hypotheses, Baguma & Ssewanyana (2008) found that the role of network infrastructure is crucial to improve service delivery and business process performance.

7.3 Research Method

To propose a SD simulation model, we combined a meta-case analysis and the SD modeling approach. Meta-case analysis is applied to systematically investigate important factors in BPC and the relationships between these factors. In this study, the meta-case analysis and its results; i.e., the factors in BPC and the relationships between these factors, were adopted from a previously published study (cf. Rosenberg et al., 2014). These data are converted into simulation model elements, such as levels and rates and are further quantified; i.e., numerical values and mathematical formulations are assigned to the model variables. In the following subsection, we illustrate the problem statement and describe our SD simulation model.

7.3.1 Process Description and Problem Statement

To illustrate the problem statement in BPC, we utilize a standard SAP reference business process "sales process" (Konstantidinis et al., 2012) and use the SD simulation approach to determine how it can be changed to achieve improvements in, e.g., employee morale, customer satisfaction, product quality, process efficiency or employee productivity.

The sales process consists of four sectors: sales, procurement, warehouse and shipping and accounting (see Figure 33). The entire process employs approximately 200 people, with 85 in the first process step, 10 in the second process step, 35 in the third process step, 59 in the fourth process step and 23 in the last process step.

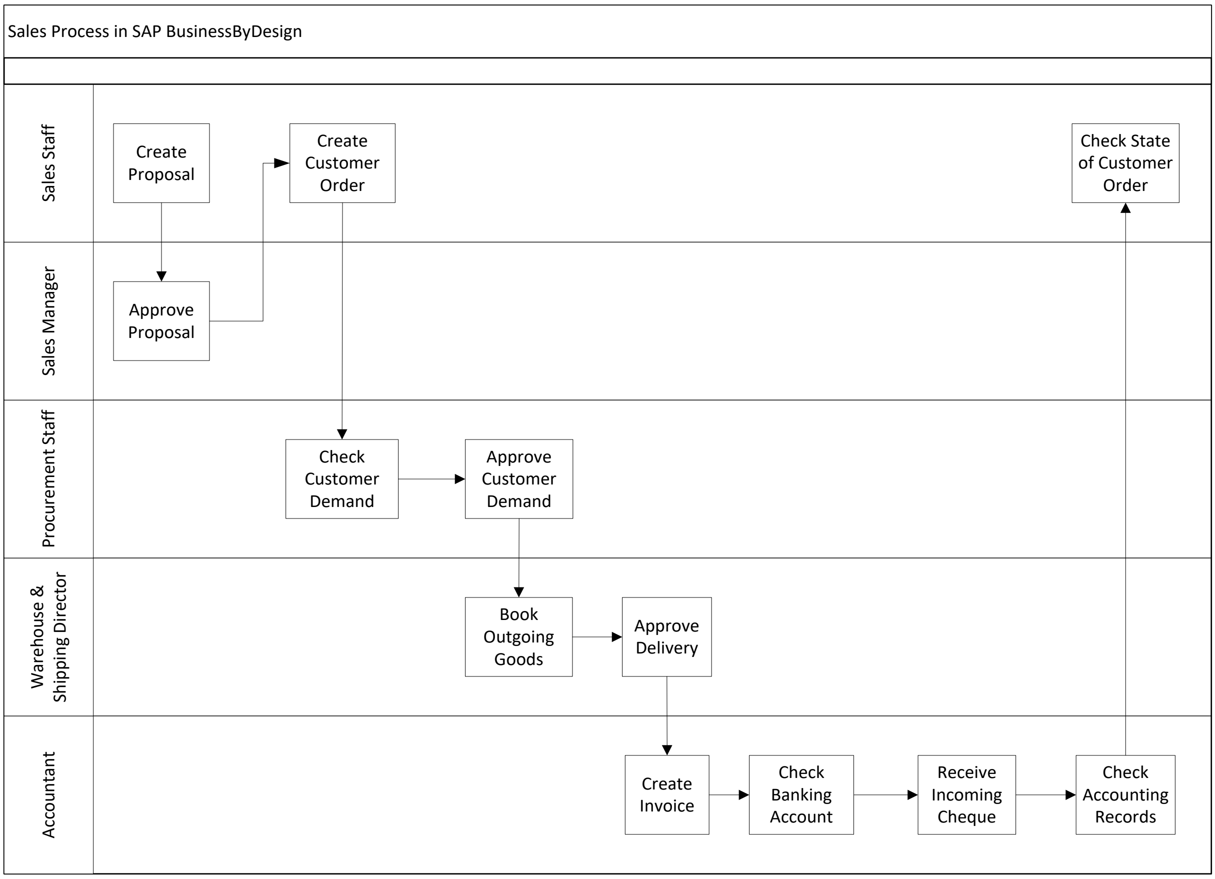

Figure 33. Sales process in SAP business by design

The sales staff is the first point of contact for new and existing customers. Initially, the sales staff creates a proposal for the customer, checks whether the products are available at the agreed-upon date and records the desired delivery date on all subsequently produced documents. The produced documents are sent to the sales manager for approval. After the approval, the sales staff creates a customer order based on the proposal. In the next step, the procurement staff reviews the customer demand generated by the order. When the review is successful, the procurement staff approves the demand. Subsequently, the warehouse and shipping director books the outgoing goods and the system creates the delivery automatically. Afterwards, the warehouse and shipping director has to approve the delivery and print the shipping order. Based on the delivered customer order, the sales staff creates a customer invoice. Then, the accountant verifies the customer account and the booking, which were created during the process. If the accountant receives the check, it will be entered to balance the open items. The accountant always checks the accounting records, which are created during the process. The sales staff can monitor the state of the order any time during the document flow.

The current situation in the process is as follows. Employee morale and satisfaction is decreasing because employees do not understand the purpose of the change. Their actual understanding of change is low. The skill level of employees is decreasing because the organization is not investing in employees' training. Each employee can process a number of transactions and achieves certain efficiency. Employee efficiency is measured by the number of transactions per full employee (FTE) per month. The initial situation shows low employee efficiency and low process quality, which are due to a high number of errors (because of the decreasing skill level and low employee morale) and low process quality. The average process cycle times are increasing and the overall process efficiency is decreasing. Poor process and product quality are reflected in low customer satisfaction. The current situation of the sales process is summarized in Figure 34.

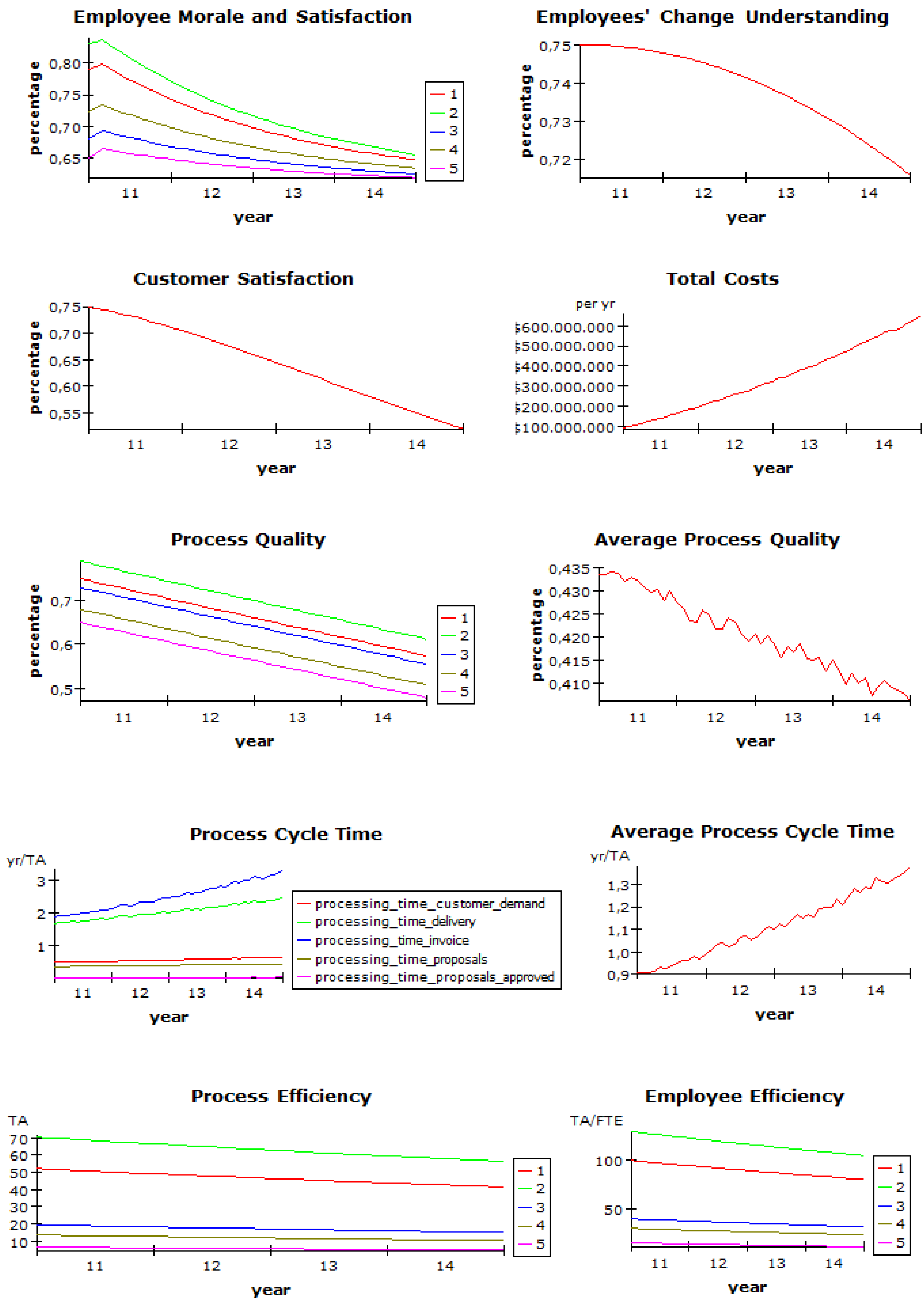

Figure 34. Current situation in the sales process

Once the process as a whole is understood, one can further investigate specific aspects of the process. The weak spots and bottlenecks can be determined and new strategic and operative goals for process changing can be prepared. The different policies and their effects will be simulated by the resulting simulation model, which we describe in the following subsection.

7.3.2 System Dynamics Model

The proposed SD model is divided into several major parts (see the Appendix). The first part refers to the management of human resources (HR). The model allows user interactions to adjust some of the key variables in the system, for example, hiring and/or downsizing the number of employees or consulting support for each simulation round. The variable ‘employee morale’, represented as a stock in the model, influences the employees’ leaving rate. If employees are not satisfied and their morale is decreasing, it has an ascending effect on the rate at which employees leave. Employee morale is indirectly influenced by the management of the communication of changes to employees. If changes are communicated to the employees, employees will understand the purpose and implications imposed by BPC initiatives and their morale will increase. If the changes are not communicated, employees will be unsure about the outcomes and about personnel and organizational changes and their morale will decrease. Another important factor in HR management is the ‘skill level of employees’, which is influenced by a number of employees, the training rate, past BPC experience and exchange ideas across an organization. Exchange ideas and past BPC experience are modeled as variables between 0 and 1, where 0 indicates not supported and 1 indicates fully supported. Employee morale and skill level are key variables that influence the overall process quality.

The second part refers to the management of the communication of changes to employees imposed by a BPC initiative. In our model, the communication of changes is measured as the accumulated effects of two inflow variables: ‘the effect of the amount of information on communication’ and ‘the effect of information quality on communication’. The effectiveness of communication is influenced by whether an organization has established a formal process that considers the formal definition of the activities, scopes and new roles. The formal process further influences the necessary amount of information and the information quality and is influenced by past BPC experience and project manager expertise. These variables influence the communication process, which in turn influences the understanding of change. Employees’ understanding of change directly influences employee morale and satisfaction.

The third part refers to the management of product delivery and customer satisfaction. A key variable represents ‘production function’, which considers the number of deployed IT and HR resources (including project manager expertise), employee skill level and employee efficiency. Employee efficiency is influenced by the ‘software tools and methods’ deployed for a project. ‘Production function’ is used as a core variable by product delivery. In our case, employees must process transactions in each process step. Production function influences how many transactions an employee is able to process. The number of transactions that need to be processed is further influenced by an error rate, which is influenced by a number of available HR resources, process quality and process volatility (such as project manager change, scope change, or client change). The process volatility can be switched on and off. Process quality is measured as a number of transactions to be processed and a number of successful transactions. Product and process quality influence customer satisfaction because the results of higher quality are satisfied customers. When the customers are satisfied, they are likely to return.

The fourth part refers to the management of the IT server, the IT infrastructure and SW methods and tools. All three variables are presented as stock variables in the model. The IT server variable changes its current value by adding the value of new IT servers or scrap IT servers. Additionally, the value of IT servers is influenced by the age of the IT servers and the number of interruptions. The IT infrastructure variable changes its current value by adding the value of the new IT infrastructure or scrap IT infrastructure. Similarly to the IT server, the IT infrastructure value is influenced by its age and by the number of interruptions. The utilization of the IT server/IT infrastructure is the division of the 'required number of IT servers/IT infrastructures' and 'the current value of IT servers/IT infrastructures'. The ideal value of the utilization of the IT server and IT infrastructure should be below 60%. Only then is it ensured that the IT servers and IT infrastructure are not working to their full capacity. Hence, a buffer for peak times is included. The variable 'SW methods and tools' changes its current value by adding the value of new SW methods and tools or scrap SW methods and tools. An employee needs at least 5 SW methods and tools to process transactions efficiently. All three variables—IT servers, IT infrastructures and SW methods and tools—influence the 'production function'.

The fifth part refers to the management of the overall process costs, which include the costs for HR resources and IT resources, which are divided into investment and operating IT costs (including costs for administration and maintenance). The overall process costs are subtracted from the defined project budget. If the overall process costs exceed the defined project budget, an indicator on the control panel issues a warning. The model offers the possibility to borrow money for a specified interest rate and pay the money back.

Additionally, the simulation model is conceived around the following basic assumptions:

- Newly hired employees are only one third as productive as experienced employees.
- Through training, newly hired employees graduate to experienced employees.
- More employees in training indicate fewer free employees available for process.
- Employee morale does not take effect immediately upon employees' departure.
- The time necessary to change the effect of employee morale is two months.
- Each employee needs at least five 'SW tools and methods' licenses to effectively work.
- Process volatility, such as project manager change or client change, is implemented as a random function.
- Consulting support is available at once, whenever we decide to rely on their service.
- Interruptions occur because of IT servers and IT infrastructure.

7.4 Simulation Results

To improve the current situation in the process, we perform the simulation in stages and observe the stepwise improvements of changes.

7.4.1 Improvement of Employees' Understanding of Change

In the first stage, we aim to improve employees' understanding of change and observe its effects on employee morale. Employees are often unsure about unknown outcomes, such as personnel and organizational changes imposed by BPC. Therefore, it is important to communicate changes to the affected people to increase their understanding of change and acceptance of the project. A communication process must be established to communicate the changes effectively. The effectiveness of the communication process is influenced by the information policy, amount of information and information quality and indirectly influenced by the formal process, management expertise and past BPC experience. The formal process considers the formal definition of the activities, scopes and roles and it is influenced by past BPC experience and management practices. As the management practices improve and BPC experience accumulates, the formal process improves and the communication process becomes more efficient.

If we assume that an organization has at least one past BPC experience and that manager practices are high (over 0.8), a suitable formal process will be established (at least 0.85). The suitable formal process positively influences the amount of information, information quality and information policy, which in turn positively influence the effectiveness of the communication process (Figure 35).

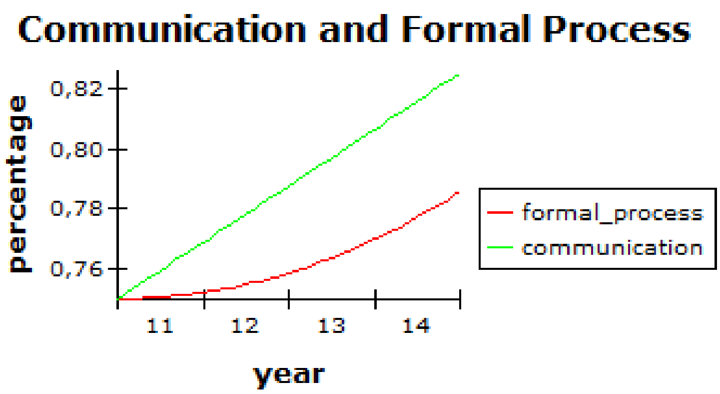

Figure 35. Simulation results for communication and formal process

Figure 36 shows the positive effect of established formal process and effective communication on employees' understanding of change and employee morale.

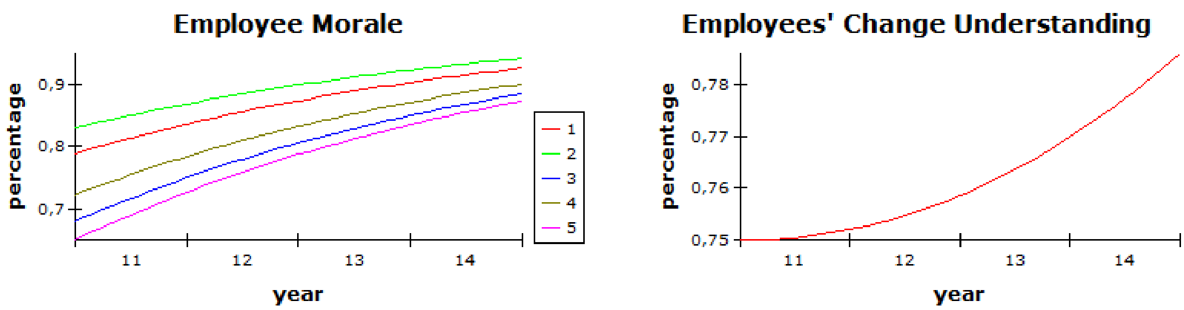

Figure 36. Simulation results for employee morale and employees' understanding of change

7.4.2 Improvement in Employees Skill Level

In the second stage, we aim to improve the skill level of employees and observe the effects of the improvement on process quality and customer satisfaction. The current employee skill level is slightly decreasing because employees do not spend any time in training due to cost reduction initiatives. Thus, employees are more likely to generate errors because they do not have the desired skill levels. Excessive errors in their tasks decrease the overall process quality and customer satisfaction because the tasks must be reworked at a later date. To increase the skill level of employees, we provide employees with appropriate training. However, the time spent in the training should not be overly high because that would produce a lag in the desired workforce. Another factor that positively influences skill level is cooperation and the exchange of ideas among organizations' business units. However, in the current situation, employees are not cooperating or exchanging ideas with other employees from a different business unit. Thus, we introduce the cooperation and idea exchange program among organizations' business units. Figure 37 shows the positive effect of training, cooperation and the idea exchange program on employees' skill level.

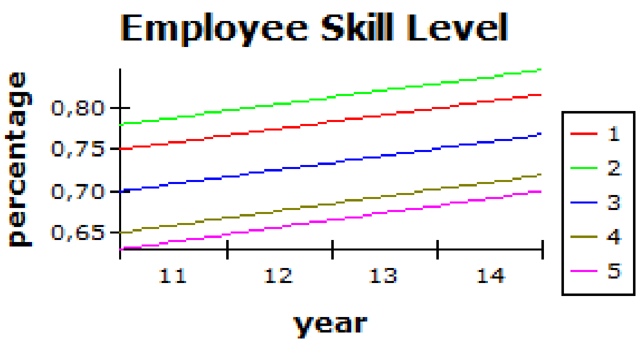

Figure 37. Simulation results for employee skill level

Higher employee skill levels have a positive effect on the overall process quality (see Figure 38) and improvements in the overall process quality leads to higher customer satisfaction (see Figure 39).

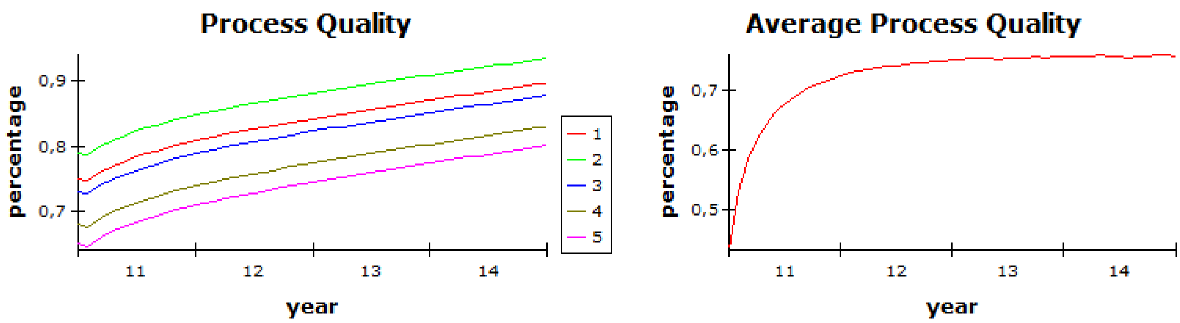

Figure 38. Simulation results for process quality

Figure 39. Simulation results for customer satisfaction

7.4.3 Improvement of Efficiency and Processing Times

In the third stage, we aim to improve employee efficiency, overall process efficiency and average processing times. In the current situation, employees do not employ any SW tools or methods. However, employees are working efficiently only if they employ an appropriate number of SW tools and methods. To increase employee efficiency, each employee will employ at least five licenses of SW methods and tools. Figure 40 shows the positive effect of the employed SW tools and methods on employee efficiency.

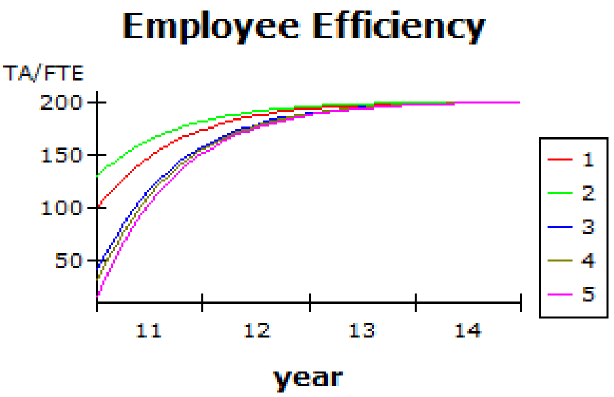

Figure 40. Simulation results for employee efficiency

The next step is to increase the overall process efficiency. The overall process efficiency is influenced by employee efficiency, employee skill level, employed IT, project manager expertise and consulting support. The employee efficiency and employee skill level factors were enhanced in previous steps. The employed IT server and IT infrastructure become obsolete after a certain amount of time. (The economic life is set to 2 years in our model.) This technological obsolescence affects the availability and performance of the employed IT. There is a decreasing trend in the performance and the availability of IT servers and IT infrastructure when they are close to the economic life. To improve IT performance and availability, we initialize substantial investments in IT servers and IT infrastructure to replace the old ones, which are insufficient and do not fulfill users' requirements. Higher project manager expertise and more consulting support also positively influence the overall process efficiency. Figure 41 shows the overall process efficiency.

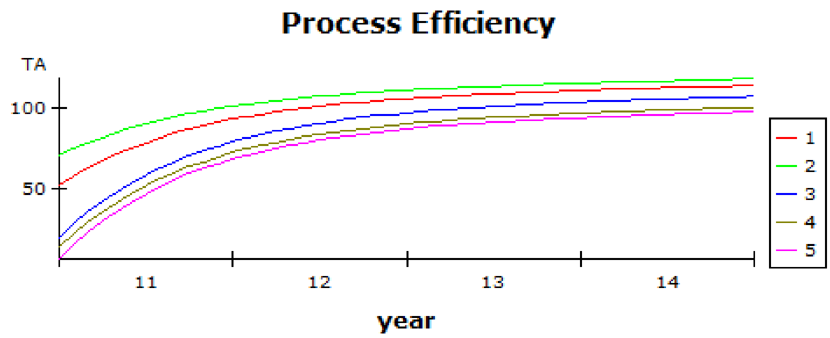

Figure 41. Simulation results for process efficiency

The overall process efficiency increased in each process step. The higher process efficiency indicates lower processing times (see Figure 42) and a higher number of processed transactions (see Figure 43).

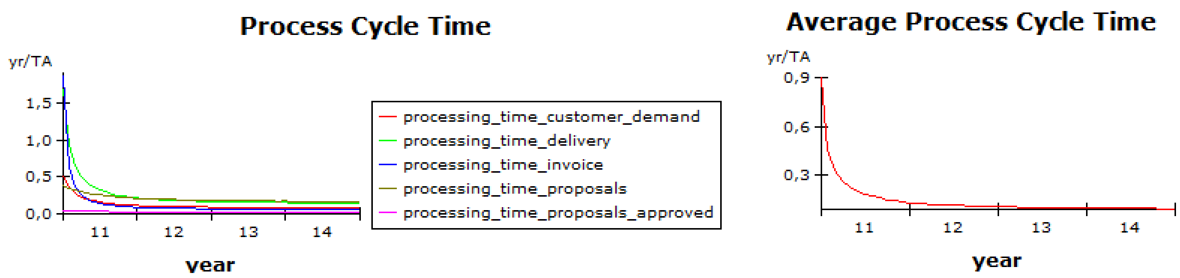

Figure 42. Simulation results for process cycle time

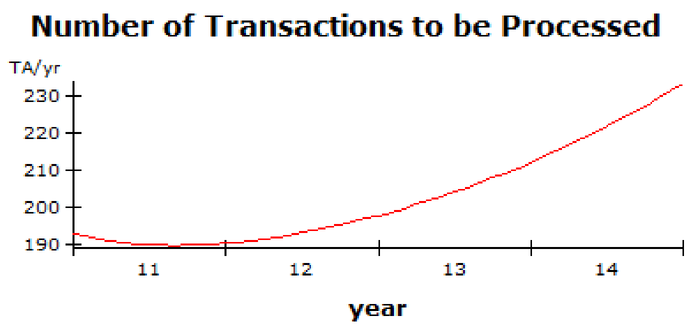

Figure 43. Simulation results for the number of transactions to be processed

7.5 Discussion

BPC projects are complex undertakings and many of them are unsuccessful. Thus, it is important to identify and understand the impact factors and interrelationships among these factors that drive BPC project success. Our simulation model is based on empirical findings. Such SD models might increase the generalizability of application in the BPC area and for practical purposes. With this work, we have shown that SD simulation is well suited to exploring process changes. In more detail, we have shown that SD is capable of creating easy-to-understand and remarkably detailed models of influence factors and interactions within BPC projects. The proposed simulation model provides an opportunity to practice various decision-making cases and observe their effects in real time. BPC researchers and practitioners can run concrete SD simulations of different variable configurations, each representing a certain set of managerial policies. Thus, various alternative solutions can be evaluated before implementing BPC projects. Furthermore, experimenting with SD simulation models enables decision makers to understand important effects, interrelationships and complex feedback loops in a more effective manner because SD models provide a graphical display that can interactively be edited and animated to demonstrate the dynamics of different decisions (Hlupic & de Vreede, 2005). BPC researchers can use the model in various experimental settings or use it for hypothesis testing.

The model might also be used as a training tool for interactive learning experience. Students can learn how to process the operational transactions in ERP processes and extract data during the business process change and analyze it to evaluate, e.g., process efficiency, customer satisfaction, employee morale, or process quality. Thus, students can enhance their practical problem-solving activities by applying theoretical concepts. Furthermore, several authors (Ben-Zvi, 2010; Madachy, 2008) found that simulation games provide an effective alternative to traditional teaching methods. The students are excited and motivated and become actively involved in the analysis process (Ben-Zvi, 2010).

However, there are some limitations that must be addressed. First, the simulation model uses hypothetical data, e.g., for employees' salary, the number of employees involved in each process step and the amount of IT employed. Thus, these data may vary substantially due to specific company characteristics or the industry and thus might represent only an approximation of a real project environment. Second, we aggregated some of the findings into broader categories because according to Forrester (1976), phenomena with similar structures may be aggregated together. However, the aggregation of some findings might lead to a simplified representation of reality.

7.6 Conclusion

This study attempts to advance the theoretical understanding of the concept of BPC and the theoretical development of simulation models for BPC projects in three important ways. First, the understanding of the elusive concept of BPC is enhanced by unveiling the dynamics of its underlying structure as result of the identification of the factors and interrelationships among them due to the meta-analysis of 130 BPC case studies. Second, the proposed SD simulation model for conducting BPC projects allows for a tangible examination of the effect of certain factors; i.e., the identification of success factors and potential bottlenecks in the project. Third, the simulation model also enables BPC researchers to test various decisions without time or cost pressures by comparing the simulation results for each anticipated policy. BPC researchers can use the model in various experimental settings or use it for hypotheses testing. Furthermore, practitioners also benefit from the results of this study. First, this study provides practitioners with a ready-to-use SD simulation model that can be applied to any BPC project. Second, practitioners may want to be able to tailor an SD simulation model for their specific project based on the important factors and interrelationships implemented in our proposed SD simulation model. Tailoring refers to customization; practitioners do not need to incorporate all of the factors of the proposed model because of individual project settings. Practitioners could test different management policies to anticipate the following steps in the BPC project. This approach increases the transparency of the underlying project and creates a better understanding of the nature of the project because SD simulation incorporates the inclusion of unintended and/or unwanted side effects caused by the application of a new policy.

Based on the strong effects and the high probability (still 60-80%) of BPC failure in modern organizations and the possibility to reduce the failure rate by applying simulation insights, this study suggests that further research in this direction is both theoretically and practically important.

PART C

1 Discussion

"All models are wrong, but some are useful." Georg Box

This thesis was motivated by an insufficient understanding of dynamic and complex interactions arising from BPC project factors and their relationships as one of the major causes of the high failure rates of BPC projects. In the following subsection we present the major results achieved in each of the six publications included in this doctoral thesis and how they helped to answer the specific research question. Next, we discuss the contributions to theory and practice and summarize the main study limitations before providing an outlook on future research.

1.1 Summary of Results

This thesis adopted a more differentiated view to identify and describe impact factors and their causal relationships by considering the complex and dynamic nature of BPC projects. We obtained the following research results:

(1) Identification of the impact factors in BPC projects

In P1 and P2 we analyzed and synthesized the useful insights from various BPC projects and systematically identified the impact factors in BPC projects. For this purpose, we analyzed and coded 130 case studies reporting from past BPC projects (P1). Based on a master list consisting of 64 factors which were grouped into 11 broader categories (cf. Jurisch, 2014), we achieved a total frequency coding number of 2,079 in our set of case studies. In the following, we describe some of the most frequently coded factors for each broader category that were coded in P1.

The first category is BPC project scopes and their outcomes. Surprisingly, none of the organization set the goals of process efficiency enhancement and process effectiveness improvement. However, as indicated in Figure 44 both factors were among the top outcomes that organizations achieved from a BPC project.

Another interesting aspect was the intended improvements in the quality of products/services which was one of the most frequently coded improvement goals. However, the results indicate that not even half of the organizations made it possible. One explanation might be mapped to the "devil's square" that indicates that only two components from the square can be changed simultaneously and the other components assimilate to the changed situation (Sneed, 2005). For example, improvements in quality and cost-saving successes are quite contradictory goals, as quality improvements are primarily associated with higher costs (Sneed, 2005). Since a reduction in costs was one of the major BPC goals it is obvious why so many organizations failed at improving the quality of their products/services.

Similarly, the variables reduction in cycle times and advances in employee morale were more frequently found in organizations that had actually planned or intended to make these at the beginning of the BPC project.

On the other hand, the price/performance ratio was not the major intended BPC project goal and the outcome was that it was reached in only 4 out of 11 cases (see Figure 44). Figure 44 shows a comparison between the intended BPC goals with the actual BPC result achieved for a number of BPC cases.

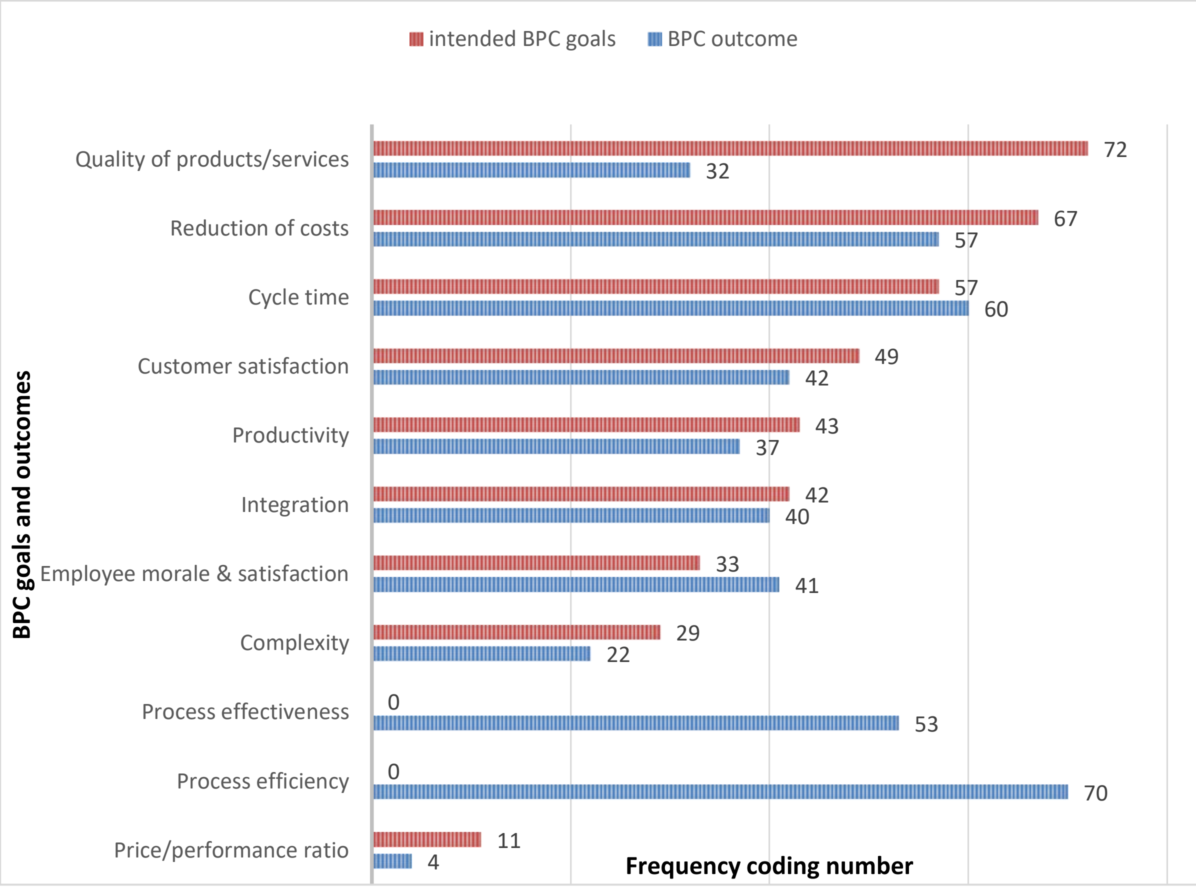

Figure 44. Comparison between BPC project goals and achieved BPC outcomes

The second category, top management support, refers to the top management vision and understanding, resource support and commitment which are some of the crucial factors in ensuring BPC project success (P1). This is in line with Guha et al. (1997) who argue that top managers have to define and communicate a change vision to ensure successful BPC implementation. Similarly, Hammer and Champy (1993) stated that a leader or senior executive who authorizes and motivates the overall project effort, is one of the most important factors in successful BPC projects. Also the recent study by Trkman (2010) found that senior management resource support and employee support are some of the most important drivers for successful BPC implementations.

The next category, project management, assumes that many aspects of project management take a central role in successful BPC implementations. In particular, a formalized governance and team structure that define new roles and responsibilities as well as the practices and the expertise level of the assigned project manager. Furthermore, the appropriate handling of stakeholder interests and risks, as well as adequate resource forecasting and managing of improvement goals, are other substantive factors in BPC implementations.

BPC projects are likely to succeed when people and the organization's structure are prepared and able to change. Therefore, the category change management is as important as top management support and project management. Change management comprises of a formal process of communication and motivational activities to increase employees' understanding of the change. In that sense, it includes the training and the empowerment of employees which are necessary factors in the development of new skills necessary for the new positions or tasks. Furthermore, our results suggest that changes should be communicated both with a high standard of information quality and at the very beginning of the BPC project. Similar results were observed in other empirical studies (e.g. Leimeister, Böhm, & Yetton, 2012; Schweiger & DeNisi, 1991). According to Leimeister, Böhm, & Yetton (2012), an organization undergoing a 'carve out' should communicate changes to employees at the very outset to minimize departures and to maximize the retention of key personnel. Otherwise, rumors would begin to circulate and as a result employees would start looking for alternative jobs (Leimeister, Böhm, & Yetton, 2012). Schweiger and DeNisi (1991) also suggested that companies pursuing a merger or an acquisition should communicate with employees as soon as possible about all of the anticipated effects of the change. They further stressed the importance of providing realistic high-quality information as a key factor for change commitment thus highlighting the importance of employee commitment and their understanding of change. Our results also suggest that an established, formal, process positively supports the appropriate amount of information to be communicated. Sometimes, top managers do not want to communicate too much information, as this could alert competitors or cause employees to leave the organization, and so they withhold the required information from the BPC project. Thus, managers should focus on areas of particular concern, such as layoffs and changes in work procedures, to ensure that proper information is communicated to employees.

Human and other resources represent another category. This category refers not only to human, technical and financial resources but also refers to immaterial goods such as the expertise, capabilities and business process know-how of the organizations' human resources.

IT based resources includes IT infrastructure, accessibility, flexibility, infrastructure configuration, reliability as well as IT know-how of human resources. Our coding results support the statement that IT resources and capabilities are important factors that drive successful BPC implementations. Another important resource factor represents consulting support. To govern BPC implementations efficiently it is important to ensure the availability of external consulting support. Our results are in line with Larsen and Myers (1997) and Jackson (1995) who stated that external consultants represent an additional workforce, bring an external point of view, subject driven expertise and provide at least a methodology which, with high probability, would be adopted by the organization.

Volatility represents another category that significantly influences the success of a BPC undertaking. Our results suggest that special attention should be paid to volatility in a competitive environment. The scope (regulatory or governmental), the schedule, the budget, the executive sponsor(s) and the project manager can all have a negative influence on the success of BPC projects.

Other important factors in BPC projects are thorough as-is-analyses of processes, cooperation and idea exchanges which are closely connected to individual and organizational learning. During the actual execution phase of a BPC initiatives, business process measurement and appropriate BPM methods and tools provide a sound footing for any activities.

Contributions to RQ#1. In P1 and P2 we provided a detailed answer to RQ#1 and showed how a systematical approach could help to synthesize the dispersed knowledge in a BPC domain. To the best of the author's knowledge, P1 and P2 are the first empirical studies that systematically investigate the impact factors in BPC projects at this level of detail. Furthermore, our results in P1 and P2 are theoretically grounded as we adopted a master list from Jurisch (2014) for the coding process which was developed based on resource-based theory (RBT).

(2) Elaboration of causal relationships between BPC impact factors

Based on our sample of 130 case studies, we explored 852 causal relationships that were coded between BPC impact factors (see P1). Not surprisingly, our results in P1 confirmed that IT is a crucial factor in BPC projects and enables, and supports, many enhancements in overall BPC project performance. Our results in P1 reported that, IT is the factor with the most influence on other BPC factors. More specifically, IT positively influences the overall productivity through the implementation of some new technology or a new established system or application. This relationship has, on the other hand, a positive effect on the reduction of cycle times which, in turn, reduces the processing costs and enhances the efficiency of the processes. Also, IT has a supporting function in training and can be used for the support of all the process management functions. On the other hand, skilled employees with a corresponding IT know-how can achieve successful IT employment. The corresponding training and experience from past BPC projects enhance the IT know-how.

The relationship between project manager practices and capabilities is important for the appropriate managing of project risks and stakeholder interests. Based on our results in P1, the project manager practices and capabilities are positively influenced by top management support. We also coded a relationship between managing stakeholder interest and project risks, as poor management of stakeholder interests might hinder the overall BPC project success. Furthermore, a rigorous and proactive management of risks and stakeholder interests, enables a better management of project scopes and goal appropriateness with fewer problems.

Volatility is the major limiting factor in BPC projects. For example, our results in P1 showed that external volatility has a significant impact on the overall BPC project success. We also found that target volatility, together with governance volatility, have a strong influence on BPC project performance. Target volatility further significantly impacts the project performance.

In P2 we further elaborated 27 relationships between employee morale and its impact factors. For this purpose, we analyzed and synthesized results reported in 65 BPC case studies. Some of the findings were aggregated into broader categories, as phenomena with similar structures might be aggregated together (Forrester, 1976).

The first factor impacting employee morale represents the factor of management vision/understanding. This factor is necessary for a better understanding of the project goals and/or project changes and therefore positively influences the factor of employee morale. Another important factor is management support that positively influences the employee understanding of the change which in turn positively influences employee morale.

Training, cycle times, reduction of costs and governance structure represent other important factors influencing employee morale. For example, trained employees are capable of supporting and transforming the organizational vision (Albizu, Olazaran, & Simon, 2004). Further, when employees drive the costs down, e.g., through reduction of cycle times, then employee morale and customer satisfaction increase.

High employee morale positively influences: (1) performance measurement which is carried out more efficiently (Harvey, 1994) and (2) productivity, as committed and motivated employees have a significant impact on productivity (Proctor & Gray, 2006).

The causal relationships identified in P1 and P2 are visualized with the help of CLD. The corresponding CLDs provide a high level of means of conceptualizing models by visualizing the feedback loop structure of the observed problem. Since the primary goal of SD models is to simulate or imitate the structure of a real system, every link in the CLD represents causal relationships between BPC factors. Behavior not only includes replicating historical experiences but also in responding to circumstances and policies that are entirely novel (Sterman, 2000). Correlations between variables reflect the past behavior of a system and thus do not represent the structure of the system. If circumstances change or new policies evolve, previously reliable correlations may break down (Sterman, 2000). Thus, the corresponding CLDs capture those relationships that underlie the causal structure of the BPC projects.

One interesting result is that many of the elaborated relationships in P1 and P2 turned out to have a positive effect. I.e. almost all loops in the proposed model are “self-reinforcing”. Self-reinforcing indicates that loops generate their own growth and that these relationships would lead to exponential improvements. However, CLDs are not capable of capturing the dynamic behavior of the variables, such as time delays. More specifically, training carried out over a long period of time might not have the required positive effect on employee morale and satisfaction and too much training can even have a negative effect and thus harm the project deadline.

The inclusion of dynamic aspects is therefore crucial to a comprehensive understanding of BPC projects. Nevertheless, CLD is a useful beginning when creating models capable of simulating the dynamic aspects of the observed phenomena as they help identify and organize principal components and feedback loops of the system under study.

Even though some of these relationships elaborated in P1 and P2 have been already mentioned in BPC studies, to the best of the author’s knowledge, these are the first studies that empirically identified the causal relationships among BPC factors.

In P3, we explore the relationships between emergent risks and the project and process performance of BPC projects. Based on Gemino et al. (2008) we identified: (1) organizational support risks (consisting of user participation and top management support), (2) volatility risks (consisting of governance volatility and target volatility) and (3) project management practices as emergent risks impacting BPC project and process performance. Our results indicate that organizational support risks have a direct impact on BPC project performance. More specifically, we supported the hypotheses that higher user participation and increased top management support substantially improve BPC project performance. Furthermore, our results supported that organizational support risks positively influence project management practices.

We also found a positive relationship between top management support and business process performance. Our results further show support for Jurisch et al.'s (2014) finding that the project performance has a strong impact on the performance of the changed business process.

However, we could not support the hypotheses that user participation directly influences business process performance or that volatility risks directly influence business process performance. These last findings are in contrast to the findings of Gemino et al. (2008). We argue that these relationships can be better explained by considering the mediating role of project management practices.

Contributions to RQ#2. While there has been much research reporting various insights from BPC projects, there has been little empirical research and evidence into the causal relationships within the BPC factors. Our research in P1 and P2 closed this gap as it elaborated the causal relationships from various BPC case studies. P1 and P2 offer new considerations and a systematical method to regard the identification of empirically founded causal relationships. P1 and P2 also showed that causal loop modeling, as a system approach, is an appropriate method for complex systems such as BPC to start with. More specifically, with its help we can visualize the complex interactions inherent in BPC projects. To the best of the author's knowledge, P1 and P2 are the first empirical studies that systematically investigate the causal relationships in BPC projects. More so, we successfully showed that the case-survey method with a causal loop model produces results that may not be possible using other methods. We further argue, that by adopting a mixed-methods approach, SD that is continuously challenged to deliver models grounded in empirical data, can enhance the generalizability and rigor of their models.

The results in P3 provide a more nuanced understanding of the emergent risks in BPC projects. We identified the emergent risks impacting BPC project and process performance empirically and provided a theoretical explanation of several relationships between emergent risks and business process performance and project performance. We also found that measuring BPC project success at the process level appears to be highly recommendable. We highlighted the importance of studying moderating and mediating factors in BPC research to reconcile the magnitude of failure rates in BPC projects.

(3) A simulation approach for analyzing the dynamic complexities in BPC projects

In P2 we proposed an SD model as a novel approach to review and consolidate the complex and dynamic findings from BPC case studies. The corresponding model is based on 65 BPC case studies and was used for conducting different scenarios for managing and understanding the behavior of employee morale as a pivotal, or core, variable determining the success of BPC projects. To illustrate the topic of employee morale in BPC projects, we utilized a standard sales process which was shaped at the beginning with many proven steps. This caused a number of reworks that increased the work backlog and finally resulted in greater pressure on the employees which negatively influenced their morale and satisfaction. This situation raised a fundamental question: – how much emphasis should be placed on reducing the time-consuming process steps in order to increase employee morale and satisfaction? To answer this question, we used two heuristics, as with their help it is easier to understand the decision-making process of decision-makers. More so, heuristics are helpful in complex systems as they simplify the modeling by not trying to include everything in a model. This, in turn, simplifies the multivariate decision process complexity by the abstraction of irrelevant details (Madachy, 2008).

In the first heuristic, we compared the average skill level of the employee against the desired average skill-level required by the project. For this purpose, we accelerated the training for new employees and observed its effect on rework cycles. Our simulation results suggested that the overall training of new employees needed to be increased stepwise to become experienced employees more rapidly. Further, this stepwise increasing of training positively affects the employees' error generation, reduces the total rework cycles and thus improves the overall morale and satisfaction of the employees. However, our simulation results also indicated that extensive training reduces the time available to complete the actual work and that too many employees had their daily tasks interrupted in order to assist in the training process of other new employees. The result of this scenario further showed that the employees found this to be tedious which, again, influenced their overall morale and satisfaction negatively.

In the second heuristic we wanted to observe the effects of the shortening of some of the proven steps on the reduction of cycle times. We, therefore, reallocated the decision-making responsibility downwards in the organizational hierarchy. Such non-value controls and approval activities along a process increased the process duration and the corresponding process costs. Our results showed that the partial elimination of the approval activity has significantly decreased the process duration. More so, these results had a positive effect on employee morale and satisfaction.

P5 offers an SD model to analyze the costs and risks associated with the decision as to whether to host IT services in the cloud or whether to operate an in-house datacenter. The model parameters in P5 were derived from literature review and were complemented by the knowledge of six IT experts. The scope of the literature review in P5 was to account for contributions regarding costs, risks, advantages and disadvantages, in the cloud computing domain, against operating an in-house datacenter. The proposed SD model in P5 is further based on the total cost of ownership (TCO) approach, since TCO considers not only the investment costs but also the costs that might change over time e.g. operation and maintenance costs. To cover the dynamic aspect of the expenses incurred in a cloud computing instance, we incorporated the function step in our simulation model. The function step allows decision-makers to specify the known peaks of server workload exactly and thus to help the allocation of needed resources better. The proposed SD model includes a user interface where decision-makers can modify the key influencing factors for both cloud computing and an in-house datacenter. Our results in P5 show that the operation of an in-house datacenter is only possible with a significant financial investment and ongoing costs. In contrast, cloud computing needs neither an own server nor an in-house datacenter. On the other hand, security and legal aspects have to be carefully considered. Furthermore, the evaluation of the model reported positive results in terms of model usefulness, intuitiveness and completeness.

In P6 we propose an integrated multi-criteria decision-making model for IT-enabled BPC. The proposed model in P6 combines SD methodology and fuzzy logic. SD is used for simulating the effects that occur in IT-enabled BPC. In turn, fuzzy logic is used for decisions and/or problems with vague, or uncertain, information. More specifically, we used the consistent fuzzy preference relation, since this relation might be used to improve decision-making consistency and effectiveness. To establish a sound basis for this model, we first derived a framework for IT-enabled BPC consisting of five main steps: (1) set objectives, (2) analysis, (3) generation of IT-solutions, (4) screen and evaluate IT-solutions and (5) prioritize IT-solutions. Based on this framework we proposed a decision-making model using which, decision-makers can rank IT-solution developments and decide in which sequence these IT-solutions should be developed and integrated into the organizations' business processes.

To show the applicability of the proposed model (P6), we performed a case study in a medium-sized German organization that planned to perform an IT-enabled BPC. The decision team consisted of six decision-makers: one CIO, one project manager, three software developers and one hardware developer, each with between 5-15 years of work experience in the field. The first step in the case study was to determine the importance weighting of each criterion by comparing the neighboring criteria with each another. To perform these pairwise comparisons for the evaluation criteria the decision-makers expressed their subjective judgments with the help of linguistic terms. E.g. less important, very important or rather important. In this step, we then merged their subjective judgements into an aggregated group preference matrix. In the second step, the decision-makers were asked to express their next subjective judgements for the preference rating of IT-solutions with respect to the considered criteria. Based on their preferences, which we again aggregated together, we could simulate the sequence of IT-solution developments and observe its effects when integrated into the organizations' business processes. The last step in the case study was the analysis and discussion of the results. The organization decided to integrate the IT-solutions based on the aggregated priority ranking. The results showed that when integrating IT-solutions into the organizations' business processes, decision-makers have to consider a large number of factors, such as the organizations' strategy, resources and technological opportunities.

P7 presents an extension of our work in P2 and illustrates how an SD simulation model can help by stepwise, or continuous, improvements in a BPC project. To show these improvements, we adopted a standard sales process from SAP Business ByDesign®. The sales process consists of four sectors and 12 process steps. The current situation in the process has several challenges and reveals a number of possible areas for improvements. More specifically, the formal communication process of changes is not established and employees involved in a BPC project do not understand the purpose of the change which becomes apparent in their decreasing morale and increasing dissatisfaction. Furthermore, the corresponding organization is not investing in training as a way to enhance the employees' skill levels. This situation is thus responsible for low employee efficiency and low process quality as well as increasing cycle times. This poor process and product/service quality, is reflected in low customer satisfaction.

Once the process, as a whole, is understood, decision-makers can investigate specific aspects of the process with the help of the proposed simulation model[11]. In more detail, they can identify the weak spots and bottlenecks based on which they can set the strategic and operative goals for process changing.

In P7 we simulate the changes, stepwise, and observe the effects immediately. Our results showed that if information quality is very low; i.e. changes are communicated very vaguely or there is a delay in communication, then the employees do not understand the message and perceive the change as implying something negative, such as job loss. The perceived communication is thus very low and employees develop strong change resistance which is seen as the opposite effect of change 'understanding' (Huq & Martin, 2006; Newman, Cowling, & Leigh, 1998). Similar results were observed when the quality of the information was very high and the changes were communicated with a two-month delay. The results showed that the quality of information by itself does not have the desired positive effect on the communication or on employees' understanding of change. More so, our results indicate that the best option to enhance employees' understanding of change is the high quality of information and no delay in the communication of planned changes.

We also found that if an organization does not have an established and suitable formal process, employees are either overloaded with too much information or receive too little information. On the other hand, our results showed that an established and suitable formal process with all necessary information, such as how much information and to whom, and in which ways, the changes should be communicated, positively influences the appropriate amount of information and thus positively influences communication and employees' understanding of change (P7).

Our results further showed that the skill level of employees might be improved by appropriate training and by introducing cooperation and an "idea exchange" program among the organizations' business units (P7). However, the time spent in training has to be managed carefully, otherwise a lag in the desired workforce might occur (P2). The improvement in the employees' skill level produced a positive effect on the overall process quality and led to higher customer satisfaction (P2).

Our results further indicated that the employment of appropriate methods and tools help to increase employee efficiency. Since, process efficiency is influenced by employee efficiency we achieved small improvements in this as well. However, to achieve a major improvement in process efficiency, other factors such as employed IT, project manager expertise and consulting support need to be carefully considered. We therefore argue that substantial investments in IT servers and IT infrastructure should be carried out to replace older ones which will probably be inadequate and so do not fulfill the users' requirements. However, the IT servers used and the

[11] We used hypothetical data when developing our SD model. The use of hypothetical data is in widespread use when developing SD simulation models. One reason is that SD models do not require detailed information or exact data which are required in short-term forecasting (Barlas, 1996). This means that only the structural and the dynamic behavior patterns of the system - are of interest in a longer term. Therefore, SD models require the matching of the major pattern of behaviors of the model and the real system rather than individual data points (Barlas, 1996). In other words, the input parameters in the SD simulation model do not have to be precise. What is important is whether the parameters have an increasing or decreasing effect (Shang et al., 2007).

IT infrastructure become obsolete after a certain amount of time especially when they are close to the end of their economic life. We also found that higher project manager expertise and more consulting support positively influence the overall process efficiency. The improvements in process efficiency triggered other improvements. In more detail, the processing times were shortened and the process costs reduced.

Contributions to RQ#3. In P2, P5, P6 and P7 we successfully showed how SD simulation models might be used for analyzing and observing the dynamic complexities in BPC projects. The interrelationships between the factors are more apparent and so their effects might be more easily observed by such a model. Decision-makers and BPC researchers can experiment with the model in order to improve their understanding of the important effects, the interrelationships and the complex feedback loops. By comprehending the resulting effects of various decisions, decision-makers gain leverage in how to improve processes by observing the dynamic results of their decisions. The proposed SD models provide a graphical display that can be edited interactively and animated to demonstrate the dynamics of different decisions. Moreover, SD treats process entities as aggregated flows over time. This assumption greatly simplifies system modeling and makes it easier to handle interconnected factors (Hlupic & de Vreede, 2005).

The model in P7 might also be used as a training tool for an interactive learning experience, since such simulation games provide an effective alternative to traditional teaching methods. When using simulation games students are more excited and motivated by SD simulation games as they are actively involved in modifying and replaying the modes (Ben-Zvi, 2010). Moreover, students might learn how to process the operational transactions in enterprise resource planning (ERP) processes.

We also showed that a more nuanced view is needed when handling complex phenomena such as BPC. To explain and visualize the complex interactions of various aspects, a combination of the two methods, case-survey and SD, is appropriate.

Table 23 summarizes the key findings of this thesis.

Publication	Findings
P1	• Empirical identification and determination of the most frequently examined impact factors in BPC case studies • Empirical identification and determination of the most frequently examined relationships in BPC projects • Creation of a conceptual model (CLD) of the problem • Demonstration of usefulness of combining case-survey methodology and SD for development of rigorous SD models
P2	• Empirical identification of impact factors on employee morale used in BPC research • Empirical identification of the relationships between employee morale and its impact factors • Creation of a conceptual model (CLD) of the problem • Creation of a simulation model for “what-if” analysis • Demonstration of usefulness of combining case-survey methodology and SD for development of rigorous SD models

P3	• Identification of emergent risks impacting BPC project and process performance • Theoretical explanation of the effects of emergent risks on BPC project and process performance • Demonstration of usefulness of including case survey methodology for development of theories in BPC research
P4	• Show that e-learning offerings should be considered from a product service system perspective (PSS) • Development of a conceptual framework for e-learning offerings based on PSS and systems approach
P5	• Analysis of the costs, risks, advantages and disadvantages of cloud computing as against an in-house datacenter • Simulation model for cost-benefit analysis of cloud computing versus the operation of an in-house datacenter
P6	• Decision framework for IT-enabled BPC • Combination of fuzzy logic and system dynamics to overcome the fuzziness in selection processes • Multi-criteria decision-making model for IT-enabled BPC
P7	• Empirically based SD simulation model for observing the effects of different "what-if" policies • Graphical display that can be edited interactively and animated to demonstrate the dynamics of different decisions • Demonstration of usefulness of combining case-survey methodology and SD for development of rigorous SD simulation models

Table 23. Overview of key results

1.2 Main Research Limitations

In interpreting the findings of this thesis, some shortcomings and limitations need to be acknowledged:

– **Case-Survey Methodology Limitations:** Case-survey analysis is subject to a number of limitations. Five of the most frequently identified validity threats to case-survey analyses are reviewed here. The first limitation is, that even though we conducted an extensive literature search we cannot guarantee that we have identified all case studies. Furthermore, some case studies did not report the necessary information and thus, were not included in the case-survey analysis. However, we are confident that any other case studies, that were not included, would not significantly affect our results. The second limitation refers to the publication bias in that significant results are more likely to be published than non-significant results (King & He, 2005). However, these published and significant results may not always be representative of the entire research population. The third limitation is that even though our coding results showed high inter-coder reliability the process of designing a scheme is bound to a certain degree of subjectivity. Any doubts in coding assignments were resolved by reaching a consensus. The fourth limitation refers to the sample size included in a case-survey. According to King and He (2005) the statistical power of detecting a genuine effect size depends on the number of case studies included in a case-survey. However, no information exists on the minimum sample size of a case-survey. The last limitation of the case-survey methodology is that it can be very time-consuming and cost-intensive to conduct. Even though Larsson (1993) argues that it is an inexpensive method, our own experience suggests that the sampling and coding of case studies are rather resource intensive stages.

- **SD Limitations:** First, the modeling process of SD offers room for criticism since the researcher can base the model on arbitrary assumptions (Sommer, 1978). As a consequence, the resulting model reflects the subjective perceptions of the researcher rather than a reproduction of the real world (Kirchgässner, 1978). We overcame this limitation by including assumptions based on empirical data rather than on subjective assumptions. The second limitation is the use of hypothetical data when developing our SD model. According to Barlas (1996) an exact matching between real data and model data is not required for a system dynamics model. The reason that no exact data is required is that SD focuses on the dynamic behavior of the combination of feedback-loops. This means, automatically, that only structural, longer-term behavior is of interest instead of detailed factors, that are required in short-term forecasting (Barlas, 1996). In SD, the main interest is to show whether the parameters have an increasing or decreasing effect on another parameter. The third limitation is about a crucial step in SD methodology, model validation. I.e. a demonstration that the model is an adequate and useful description of the real system with respect to the problem(s) of concern (Barlas & Carpenter, 1990). SD has often been criticized for relying too much on informal, subjective and qualitative validation procedures (Ansoff & Slevin, 1968; Nordhaus, 1973; Zellner, 1980). Even though SD researchers have responded to such criticisms, until today no clear evidence on an established definition of model validity has managed to prevail. Thus, SD models can be validated in many different ways. We therefore used policy analysis to validate the behavior of the proposed SD models. The fourth limitation refers to the relative strength of the causal loops. Causal loops have different strengths and some are more important than others. This indicates that the mere presence of a loop in a CLD does not necessarily mean that the loop is significant in explaining the behavior of the system (Hayward & Boswell, 2014).

1.3 Implications

These findings incorporate a number of insights and contributions that have implications on both theory and practice and will be discussed in the following subsections.

1.3.1 Implications for Research

The results of this thesis bear several theoretical contributions to the research on BPC projects and the SD domain:

- **Impact factors:** The first implication is the synthesis of BPC knowledge, which was mainly dispersed in single case studies reporting past BPC project experiences. For this purpose, we applied the case-survey analysis in P1 and P2 and explored the insights of 130 case studies to identify the impact factors in BPC projects empirically. According to Whetten (1989), the identification of the impact factors as part of the explanation of the social or individual phenomena of interest is the first step to theory-development. Whetten (1989) further suggests to validate the factors based on two criteria: (1) comprehensiveness; i.e. whether all relevant factors are included in the study and (2) parsimony; i.e. whether factors with little additional value to our understanding and thus should be deleted. In P1 and P2 we ensured comprehensiveness by including factors representing different aspects of the study design and several control factors, such as research design, publication outlet and the time frames of the case studies. Regarding parsimony, in P1 and P2 we treated understudied factors as significant as such factors, that were coded only once, might still have a significant impact on the overall BPC projects success. In overall, our results in P1 highlight the importance of the factor of "top management support" as the main facilitator for successful BPC. This is consistent with the work of Hammer & Champy (1993) who reported that "top management support" is one of the critical success factors in BPC projects. This result indicates that BPC implementations follow a top down approach rather than an employee driven strategy. Our findings in P1 are further consistent with the theoretical reasoning of Trkman (2010) who argues that BPC must be aligned to the organizational strategy in order to achieve a long-term success and performance improvements. We also contributed to the debate whether IT is critical success factor in BPC or not. In P1 we found that IT is a major driver for almost all of the intended improvement goals, especially for the reduction of the costs or reduction of the cycle times.

- **Causal relationships:** The second implication refers to the identification of causal relationships among the impact factors. With the knowledge gained from the empirical case-survey analysis of 130 BPC case studies, we comprehensive described the causal relationships and contributed to better understanding of the anatomy of different relationships (P1, P2 and P3). These cause-and-effect relationships are integrated in a conceptual model; i.e. CLD. According to Whetten (1989) the identification of cause-and-effect relationships is the second important step to theory-development. Overall, the empirical study showed that the reality of BPC relationships is more complex and sophisticated. For example, our results in P1, P2 and P7 showed that there is a positive relationship between training, experiences from previous BPC projects and employees' understanding of change. We also suggest, that the communication of changes to employees has a positive effect on the overall success of BPC initiatives (P1). This is in line with other BPC researchers, who highlight the importance of the relationship between communication and BPC project success (Albizu, Olazaran, & Simon, 2004; McAdam & Corrigan, 2001; Thong, Yap, & Seah, 2000). Communication is, on the other side, influenced by information policy, formal process, information quantity and by top management practices. The results in P1 also confirmed that IT enables many improvements, such as a reduction in costs, reduction of cycle times and customer satisfaction. On the other hand, our results in P1 could not confirm the relationship between IT and competitive advantage, as stated by Bharadwaj (2000). This highlights the argumentation by Picot, Reichwald and Wigand (2003) that IT is influenced by the business model and enables business process but on the other hand the value is created by the business processes. The results in P2 confirmed the positive relationship between employee morale and customer satisfaction (Proctor & Gray, 2006) as well as the positive relationship between employee morale and productivity and performance measurement (Harvey, 1994). In P2 we further confirmed that training is a key factor in influencing employee morale and that trained employees increases the skills and capabilities of the employees (Albizu, Olazaran & Simon, 2004). In P2 we also found a positive relationship between skilled employees and the successful transformation of organizational vision. This is in line with Newman, Cowling & Simon (2004) who argue that employees with a high skill level are more capable, and willing, to support and transform the organization vision. In P3 we empirically tested the relationships between emergent risks and the project and process performance of BPC projects. Our results in P3 could confirm the positive relationships between organizational support risks and BPC project performance, as stated by Gemino et al. (2008). In P3 we suggested a positive relationship between top management support and business process performance, which is in line with Jurisch et al. (2014).

- **Simulation of dynamic complexities in BPC:** The third implication refers to the understanding of how cause-and-effect relationships between the impact factors change over time. It allows decomposing the behavioral system into its impact components and then integrating them into a whole that can be easily visualized and simulated. In P2, P5, P6 and P7 we have shown that SD is capable of creating easily graspable and remarkably detailed models of influence factors and interactions within BPC projects. For example, we found that changes should be communicated with a high information quality at the very beginning of the BPC projects (P7), otherwise, rumors could begin to circulate and employees could start looking for alternative jobs. Furthermore, our results in P7 highlight that even if top managers do not exactly know what the changes will be, and therefore are unwilling to communicate the changes to the employees or they communicate them vaguely to retain flexibility, employees would not understand the purpose of the change and might, again, start to search for alternative jobs. In P2 we found that an increase between 30%-60% of training overhead positively influences the employee morale and overall productivity. On the other hand, we found that if the time spent in training is reduced below 30% or increased over 60%, the overall employee satisfaction decreases and causes increased cycle times, delays on delivery times and increases in the time pressure on employees.

- **Methodology:** With respect to the SD community, we contributed to the qualitative data used in SD. We suggested that a case-survey methodology should be used when important data cannot be extracted from the primary data, such as interviews or surveys. With this approach the social desirability response bias can be significantly reduced; I.e. an interviewee may respond to a researcher's questions in a manner they think is expected of them or presents them in a favorable manner (Du, Bhattacharya, & Sankar, 2007). Our results in P1, P2, P3 and P7 have shown that case-survey analysis is a powerful approach for collecting and analyzing qualitative data in complex systems such as BPC projects. For example, in P3 we showed that case-survey analysis is a useful approach for theory building. In P1, P2 and P7 we suggested to combine case-survey analysis and system dynamics for complex and dynamic systems such as BPC projects.

- **Empirical simulation model:** In P2 and P7 we proposed simulation models, grounded in empirical findings, to build theoretical understanding of complex systems such as BPC. Such empirical models, as proposed in P2 and P7, increase their generalizability and rigor, since they are based on multiple case studies and various domains. In behavioral science, such empirical grounded models can serve for theory building and testing. In the design science context, such empirical models can be used for investigating the actual effects of design artefacts. Our research therefore, also addresses the call for more research in the development of empirical SD simulation models towards higher acceptance in BPC research.

1.3.2 Implications for Practice

In addition to theoretical contributions, this thesis also provides several implications for decision-makers in BPC projects:

- **Understand the impact factors and their relationships:** To understand the impact factors and their relationships is fruitful in order to gain a first insight into how to implement BPC. For example, the results in P1 and P2 highlight the importance of soft variables in BPC projects, such as employee morale, employee's change understanding, quality of communication, business process know-how, customer satisfaction or project manager practices. By neglecting these variables, decision-makers would run the risk of BPC project failure. For example, high employee morale positively influences product and/or service quality and thus indirectly leads to better customer satisfaction (P1 and P2). Our results further highlight the management of emergent risks, which might evolve during the course of a BPC project, such as the change of an executive sponsor. Specifically, we identified user participation, top management support, governance volatility and target volatility as critical emergent risks in BPC projects. These kinds of risk factors result in different degrees of changes and influence the whole success of change initiative (Kanter, Stein, & Jick, 1992). We also found that consulting support is necessary when conducting BPC implementations (P1 and P7). However, the expenses incurred by consulting support in BPC projects has to be considered carefully, as it can lead to a steep increase in costs that may well exceed the expected level. Finally, decision-makers benefit from the discoveries of this thesis by gaining deep insights into the important impact factors and their interrelationships.

- **Decision-making tool for managing and analyzing the dynamics inherent in BPC projects:** The proposed SD models in P2, P5, P6 and P7 provide the opportunity to analyze and manage courses of action in the setting of a management laboratory; i.e. to learn in a virtual reality. Decision-makers do not have to become proficient in solving differential equations to gain insights into the dynamic processes of BPC projects. The proposed SD simulation models allow decision-makers to refine their view of the problem, as the output of a simulation run becomes the input to another one until a satisfactory level of know-how is achieved. This allows decision-makers to analyze the effects of different variable configurations, each representing a certain set of managerial policies. The results of such analyses can be further translated into concrete BPC implementation guidelines as well as support for an optimal allocation of economic, IT and human resources, depending on the underlying BPC goals. For example, the results in P5 confirmed that for many organizations it is relatively challenging to determine the costs caused by offering own services in the cloud with the costs caused by an own datacenter. With the SD model proposed in P5 decision-makers can perform different scenarios with different configurations and so can observe the effects of their decisions immediately. In P6 we proposed to classify the different implementation goals into dominance and non-dominance sets, since for many companies it is not feasible to implement all goals at once. Therefore, the companies should concentrate on the dominant policies and then gradually move into other policies, which have been classified as less important to the overall BPC project. Our results in P2 highlight the stepwise acceleration of the training for newly hired employees in order to reduce the rework cycles arising from employees' error generation. Furthermore, the results in P2 confirmed that if an organization or a manager holds a positive attitude toward employees' reliability and goodwill in a different decision situation, the performance and morale of the employees would increase. In P7 we found that the effectiveness of the communication process can be achieved when a formal process of communication is defined. Furthermore, decision-makers should pay great attention to the factors: employee efficiency, employee skill level, employed IT, project manager expertise and consulting support when enhancing the overall process efficiency (P7).

– **Enhancing decision-makers mental models and their decision-making process:** The purpose of SD is not to produce plans, but rather to change the decision-makers' mental models and so to enhance their decision-making process (Milling & Stumpfe, 2000). Even experts have great difficulty in inferring the behavior of complex dynamic systems accurately, since the human mind is bound by various limitations of attention, memory and information processing capability (Sterman, 1992). The proposed SD models in P2, P5, P6 and P7 therefore overcome some of these limitations. SD models are, according to Sterman (1992): (1) explicit and their assumptions are open to all for review, (2) can infallibly compute the logical consequence of the modeler's assumptions, (3) are able to interrelate many factors simultaneously and (4) can be a simulation under controlled conditions. Once, the decision-makers have gained experience with such simulation models, they can encode the inferences from their experiences and develop more comprehensive mental models for interpreting that experience (Gary & Wood, 2011).

1.4 Future Research

There are several challenging opportunities for extensions to the work discussed in this thesis, including:

– **The combination of different behavioral methods with System Dynamics for the exploration of structural dominance in CLD:** The combination of different behavioral methods with SD for the exploration of the structural dominance of the causal effects would have a direct impact on the strength of CLD as a theory-building tool which would be worthwhile for both the SD and BPC domains. As a consequence, the use of advanced mathematical techniques or customized tools is not required.

- **Applying an SD model as decision-making model in a case study:** The proposed SD model in P7 has not been applied as a decision-making model in a real BPC project yet. Therefore, a next step could be to apply the proposed SD model in, at or with an industry partner in order for them to assess and improve their business processes. The advantage would be that the decision-makers who apply this model as a decision-making model would provide us with additional empirical data for parameterizing and calibrating the model. Furthermore, the model should be applied in a different domain or an organizational and national setting for calibration purposes.

- **Further developing the SD model as a business game:** The proposed SD models presented in this thesis have been run in a detached mode without extensive user interaction. Therefore, a next step could be an extension of the SD models into a business game. The development and use of business games for students and managers has gained importance in Information Systems in the last decades, as it is already ubiquitous in aerospace and military applications. The employment of business games for improving and enriching the learning experience of students proved to be more efficient than traditional learning methods and approaches. Traditional education approaches are often not tailored to capture the many complexities of BPC projects. Students and managers need a way to scan their memory for similar situations when analyzing a decision. (Doyle & Ford, 1998; Wang & Chen, 2012). Therefore, business games present a rare chance to convey knowledge and thereby allowing the decision maker the experience of the phenomena of interest.

- **Integration of various types of models and** to **continuously improve the SD model:** In the spirit of continuous process improvement, SD models should be continuously enhanced, refined and improved by industry-specific variables. Variables such as the goals, constraints and objectives of the organization, that may have changed, as well as the process environment being modeled (Madachy, 2008). Additionally, technological advances allow the integration of models of various types and bring more advance usage. For instance, SD will be one of several techniques to further the theories and practices of BPC as will discrete event methods, agent-based modeling or their combinations. Moreover, a self-controlled improvement of SD models with accurate data from the actual BPC projects may evolve as a result of machine learning.

2 Conclusion

Despite the considerable experience gained over the last three decades, improving and managing BPC projects is still an on-going challenge for BPC practitioners and researchers alike. Although BPC projects increase the risk of failure and extreme financial losses, the respective organizations need to adapt to new environmental demands, new technological advances, new customer demands, new market drivers and new organization policies (Haveman, 1992) to remain competitive. Despite the importance of BPC, a holistic understanding of the complex and dynamic nature of BPC projects is not yet to be found in the literature. This doctoral thesis therefore addresses this gap by proposing an SD simulation model that is capable of capturing the complex, and dynamic, BPC behavior resulting from nonlinear structures, such as rework and learning curves. We employed a mixed-methods research strategy to address the research objectives empirically. This study advanced the theoretical understanding of the concept of BPC and the theoretical development of simulation models for BPC projects. More specifically, the understanding of the elusive concept of BPC is enhanced by the unveiling of the dynamics of its underlying structure. As a result of the identification of these dynamics and their interrelationships which came as a result of the meta-analysis of the 130 BPC case studies. We demonstrated the usefulness of including an SD simulation approach in BPC research as a means of experimentation to test various decisions, without time or cost pressures, by comparing the simulation results for each anticipated policy. BPC researchers can use the model in various experimental settings or use it for hypotheses testing. The proposed SD model increases the transparency of the underlying project and creates a better understanding of the nature of the project because SD simulation incorporates the inclusion of unintended and/or unwanted side effects caused by the application of a new policy.

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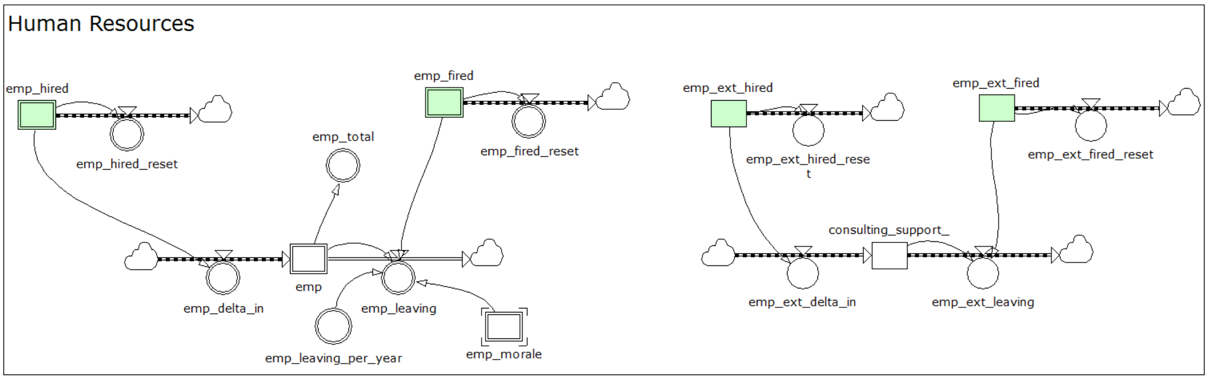
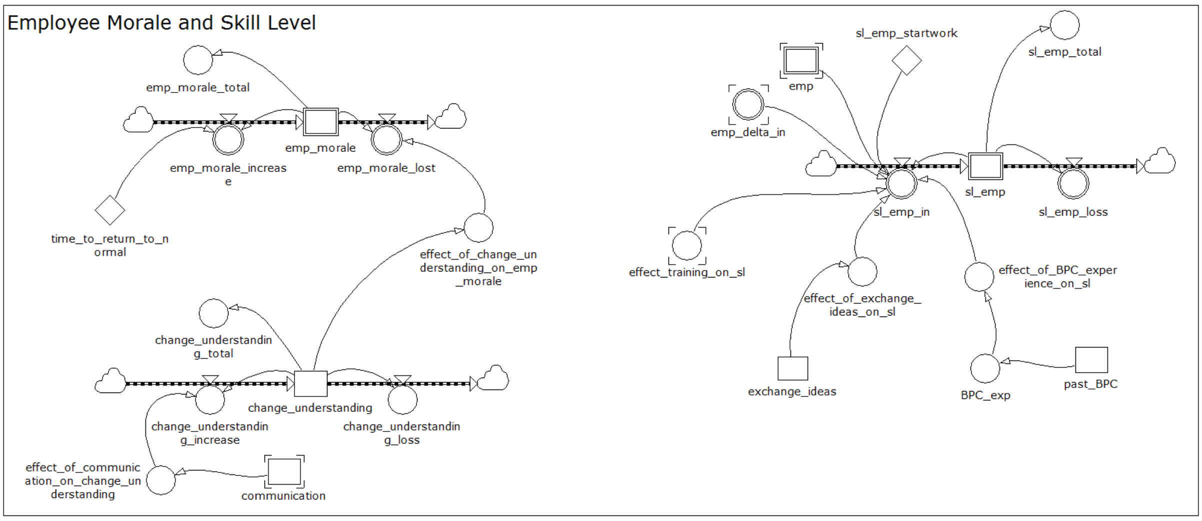
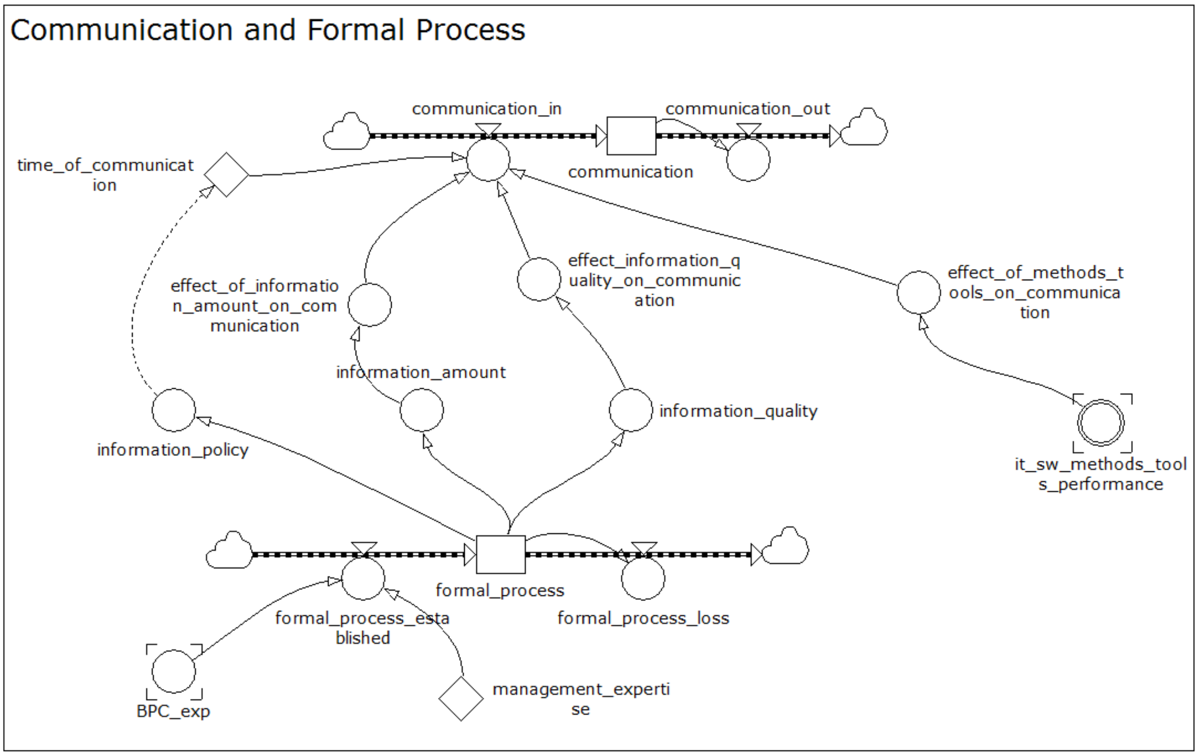
Appendix A: Simulation Model

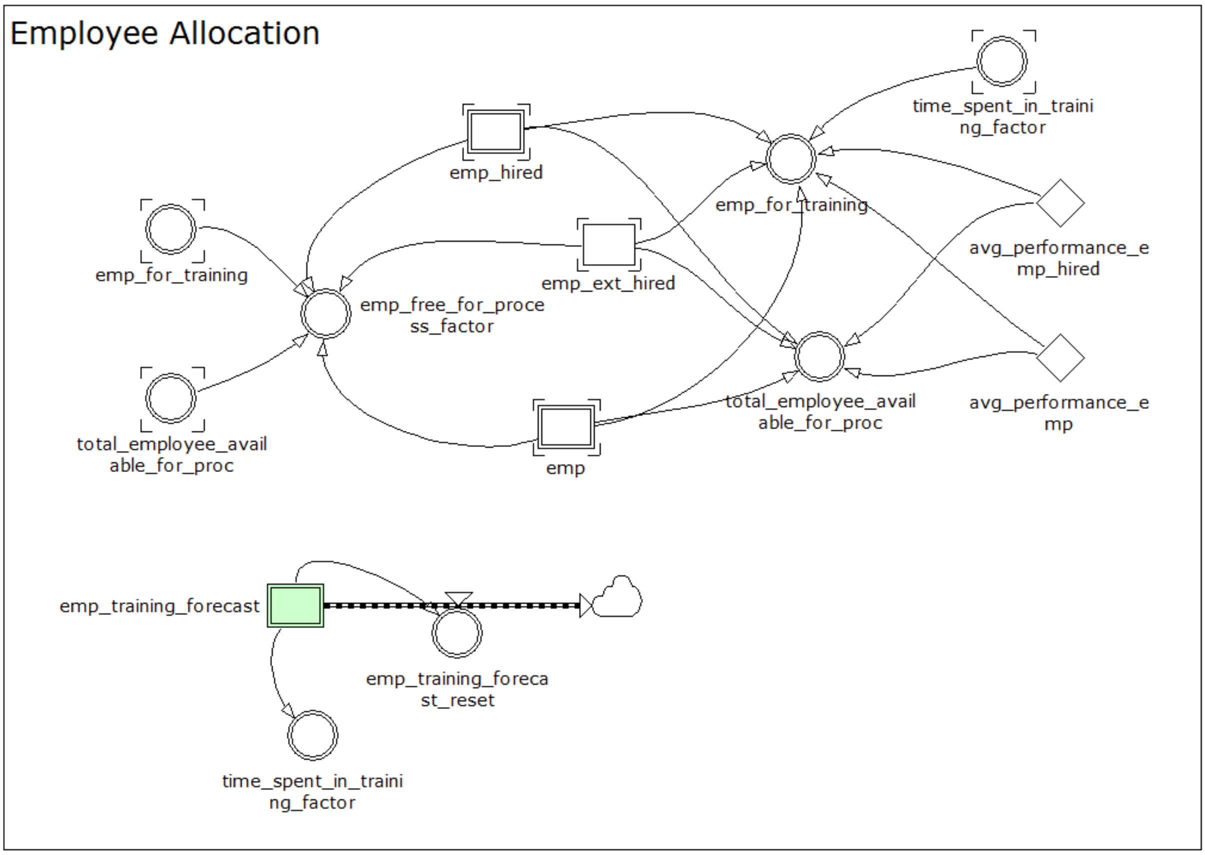


The model "human resources" allows the management of the asset of human capital. This includes the hiring and downsizing of intern and extern project's human resources. This model further demonstrates the relationship between employee morale and employee leaving.

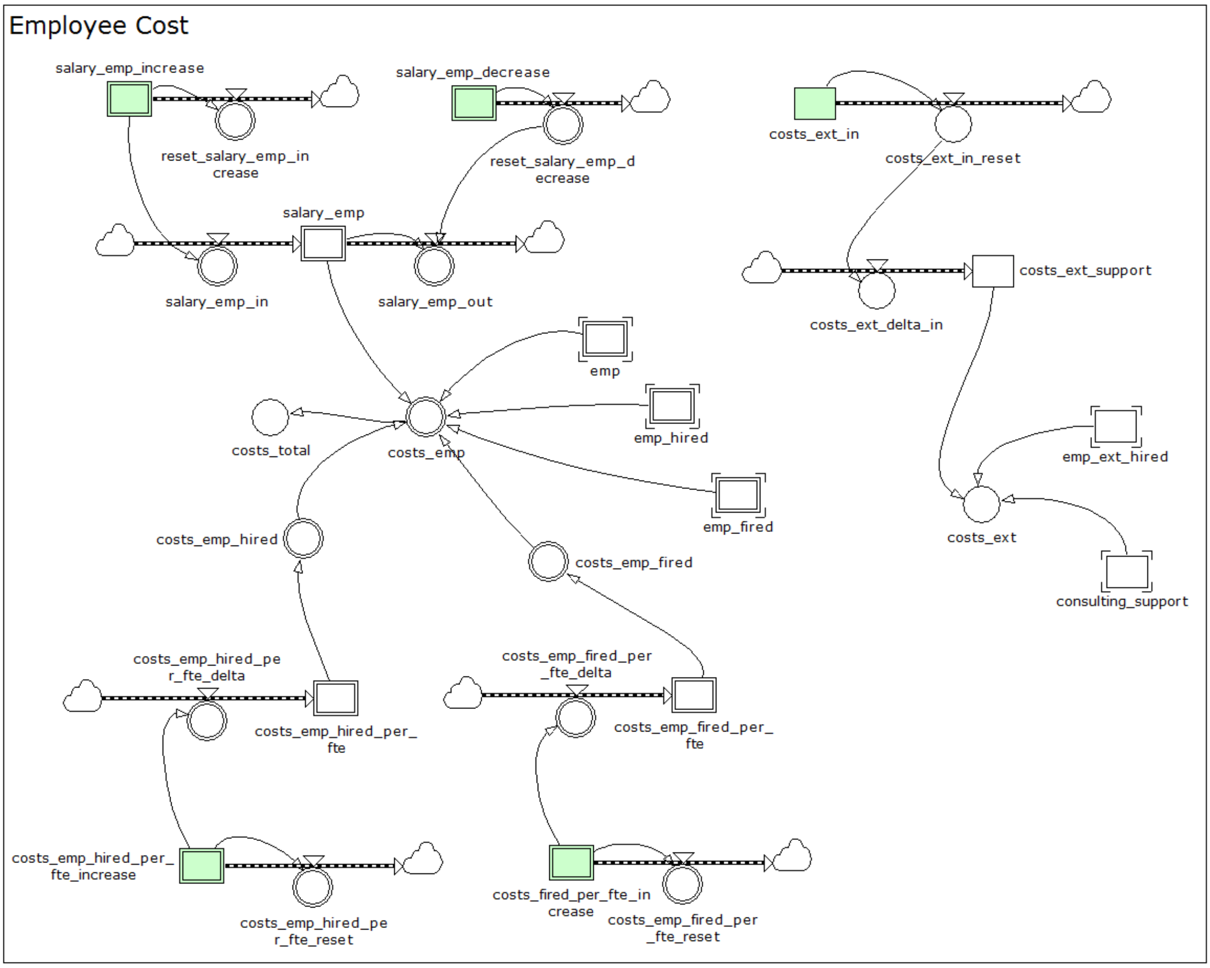




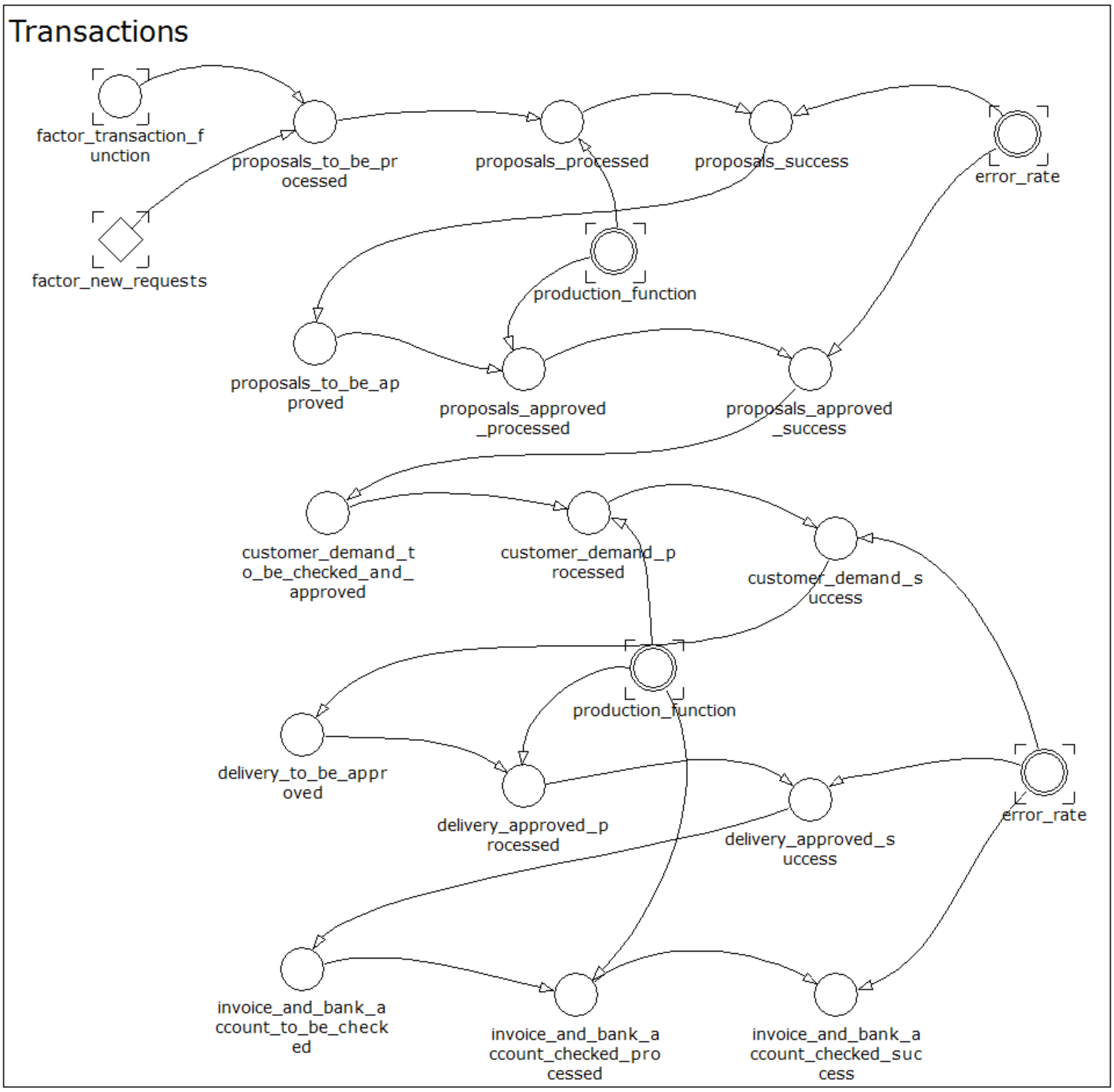
The models "employee morale and skill level" and "communication and formal process" demonstrates the importance of so-called "soft" variables and their overall impact on project performance. Downsizing, understanding of the BPC project, quality of communication, or established formal process are all situations in which these "soft" variables play a critical role in the success of a BPC project.



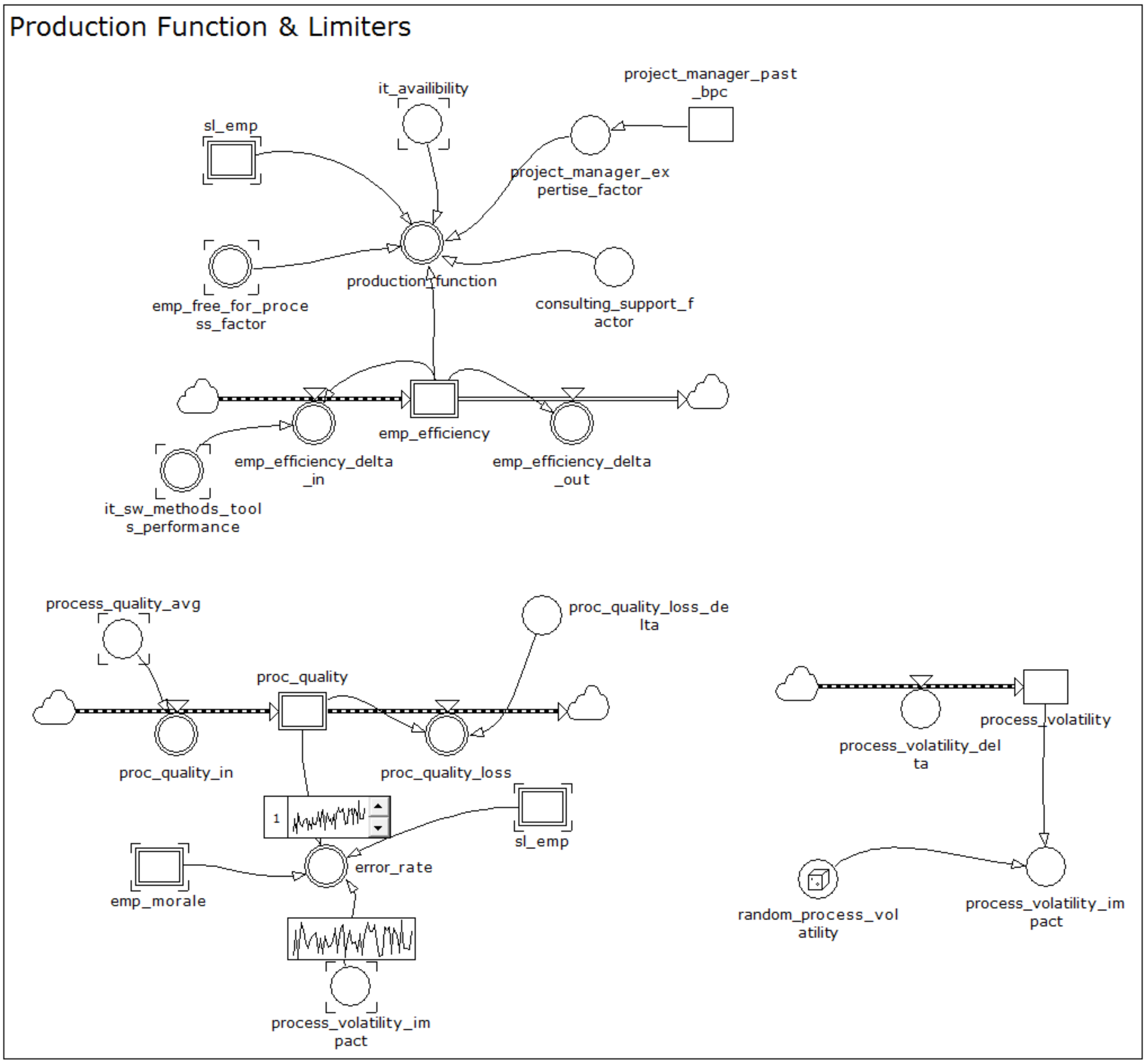
The model “employee allocation” displays the time allocation of human resources. It further demonstrates the causal relationships between the number of employees, newly hired employees, time spend in training and employees available for BPC project.



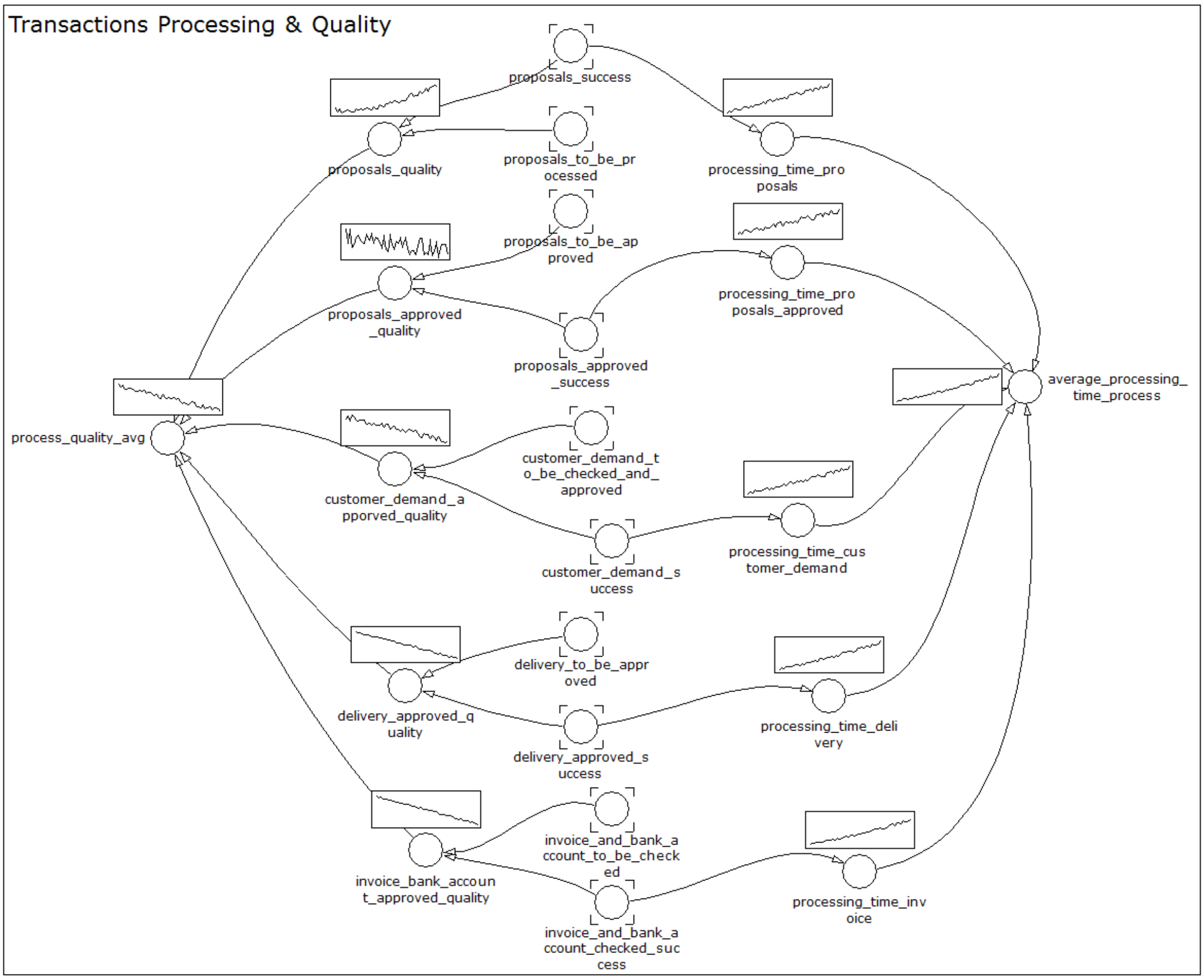
The model "employee cost" allows the management of the wage costs of the company's internal and external personnel and shows the total costs spend on the employment cost. They are calculated by multiplying the actual amount of employees by the costs resulting from the employment cost.



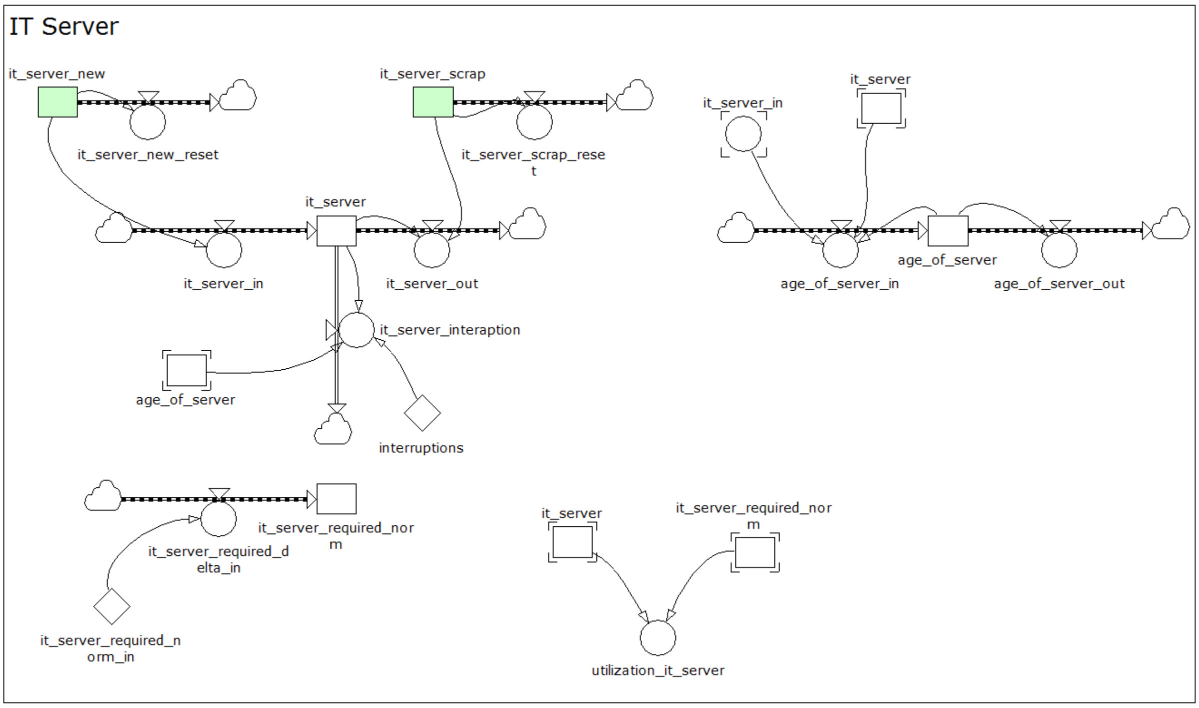
The model "transaction" displays the number of transactions that need to be processed. We defined five different transactions that can be mapped to the process steps along the business process. Two important factors affect the execution of these transaction: production function, which gives the number of effective production of personnel as well as successful employment of IT resources and tools and methods and error rate that indicates the number of errors generated by the company's employee.



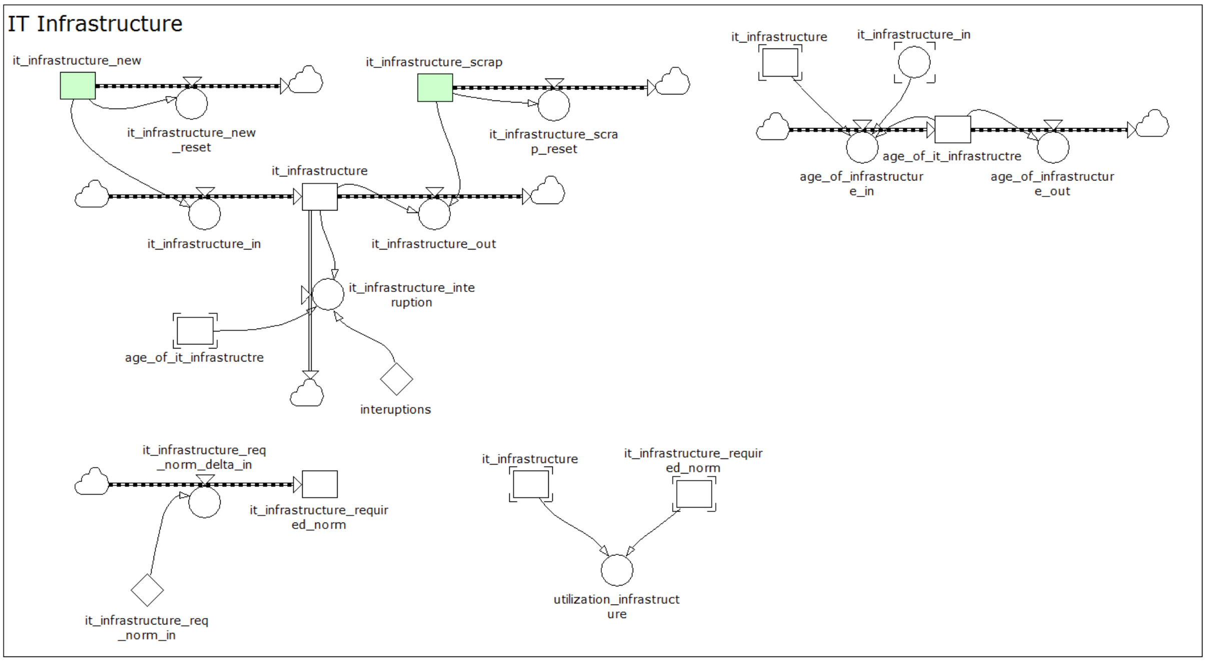
The model "production function and limiters" shows the effectiveness and efficiency of the employees. It is affected by several factors such as employees' skill level, number of employees available for project, project manager expertise, consulting support and the employed IT resources. Error rate represents the number of incorrect tasks that need to be reworked later. It is affected by process volatility, employee morale and employee skill level.



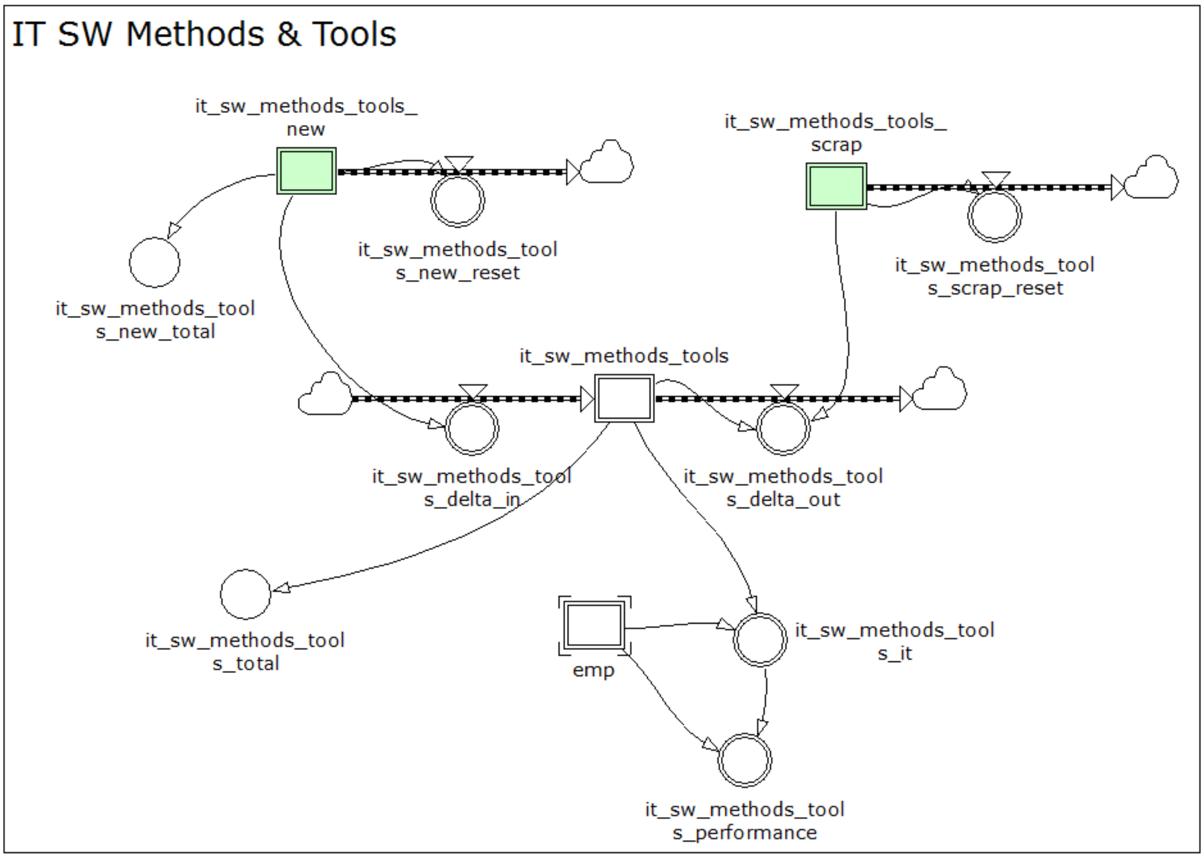
The model “transactions processing and quality” displays the average process quality and average processing time of the overall process. The overall transaction quality is calculated as quotient of successful transactions divided by the transactions to be processed. The average processing time is calculated as quotient of employee productivity factor divided by the number of successful transactions.



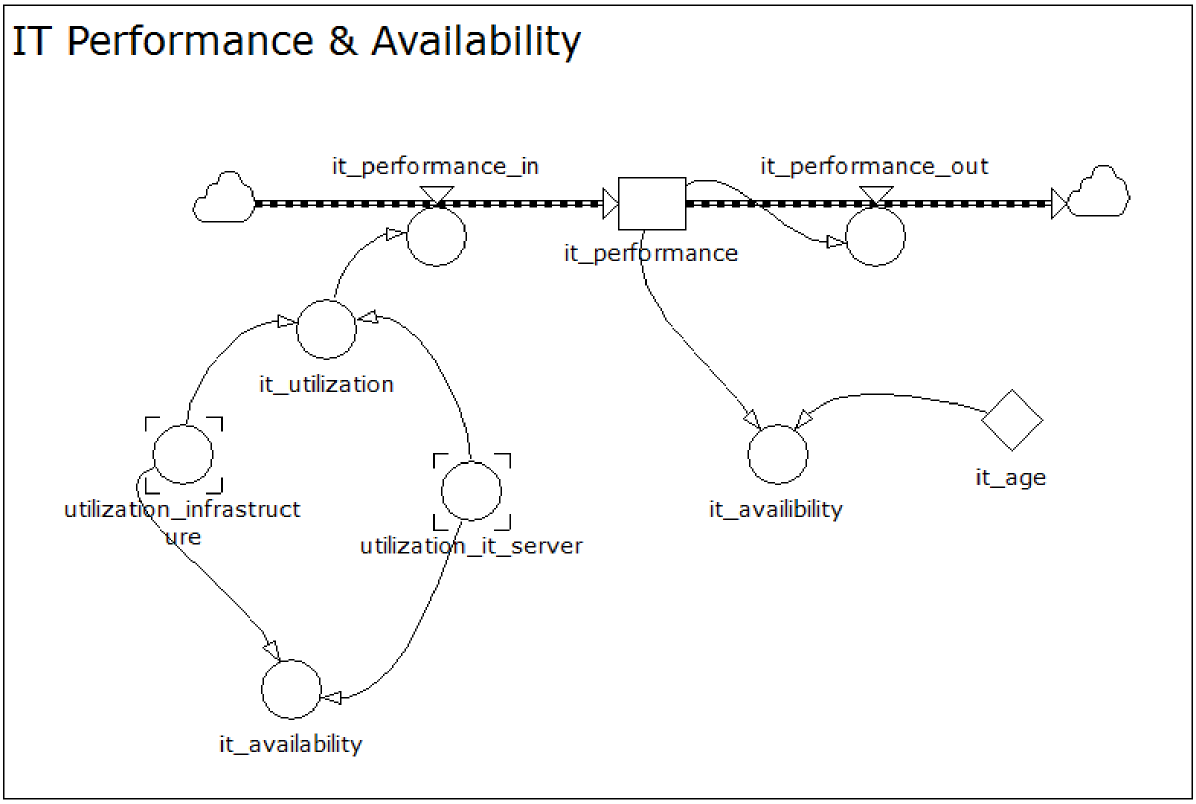
In the model "IT Server" decision-makers can invest in new IT server or dispose them. These decisions lead to variation in the average of IT server. The IT server utilization is represented as quotient of number of server divided by number of IT server required for a project.



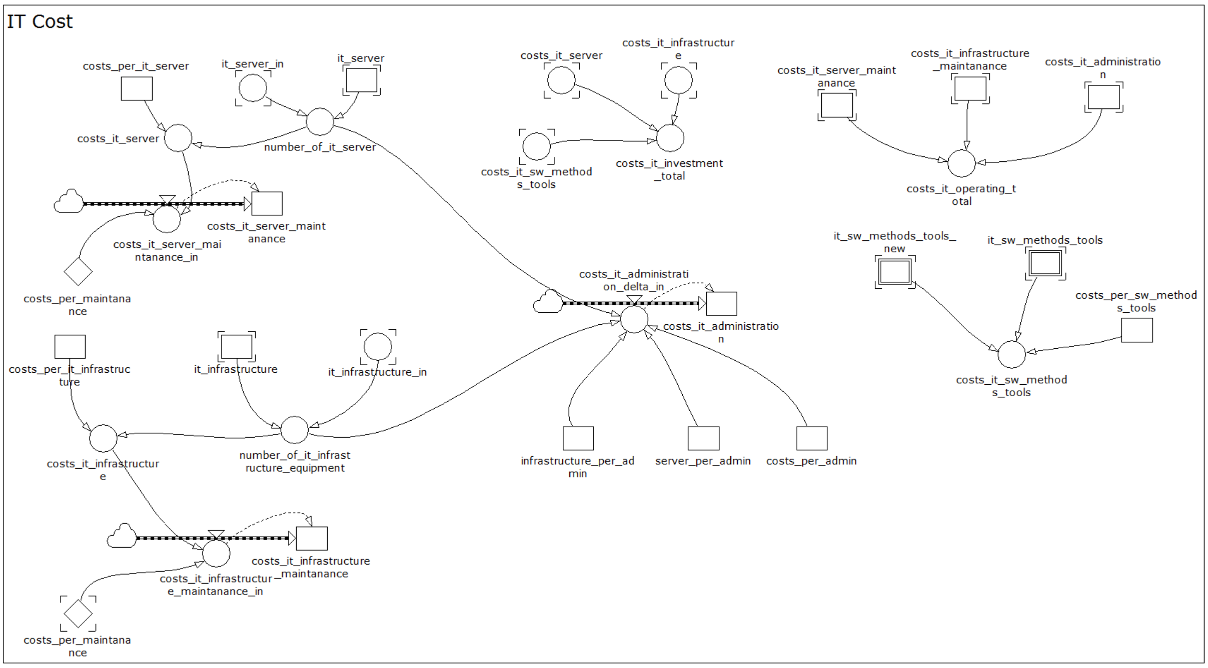
In the model "IT Infrastructure" decision-makers can invest in new IT infrastructure or dispose them. These decisions lead to variation in the average of IT infrastructure. The IT infrastructure utilization is represented as quotient of number of IT infrastructure divided by number of IT infrastructure required for a project.



In the model "IT SW methods and tools" decision-makers can manage the amount of software methods and tools. Together with IT server and infrastructure, IT SW methods and tools represent an important factor with which help a company may achieve a competitive advantage.

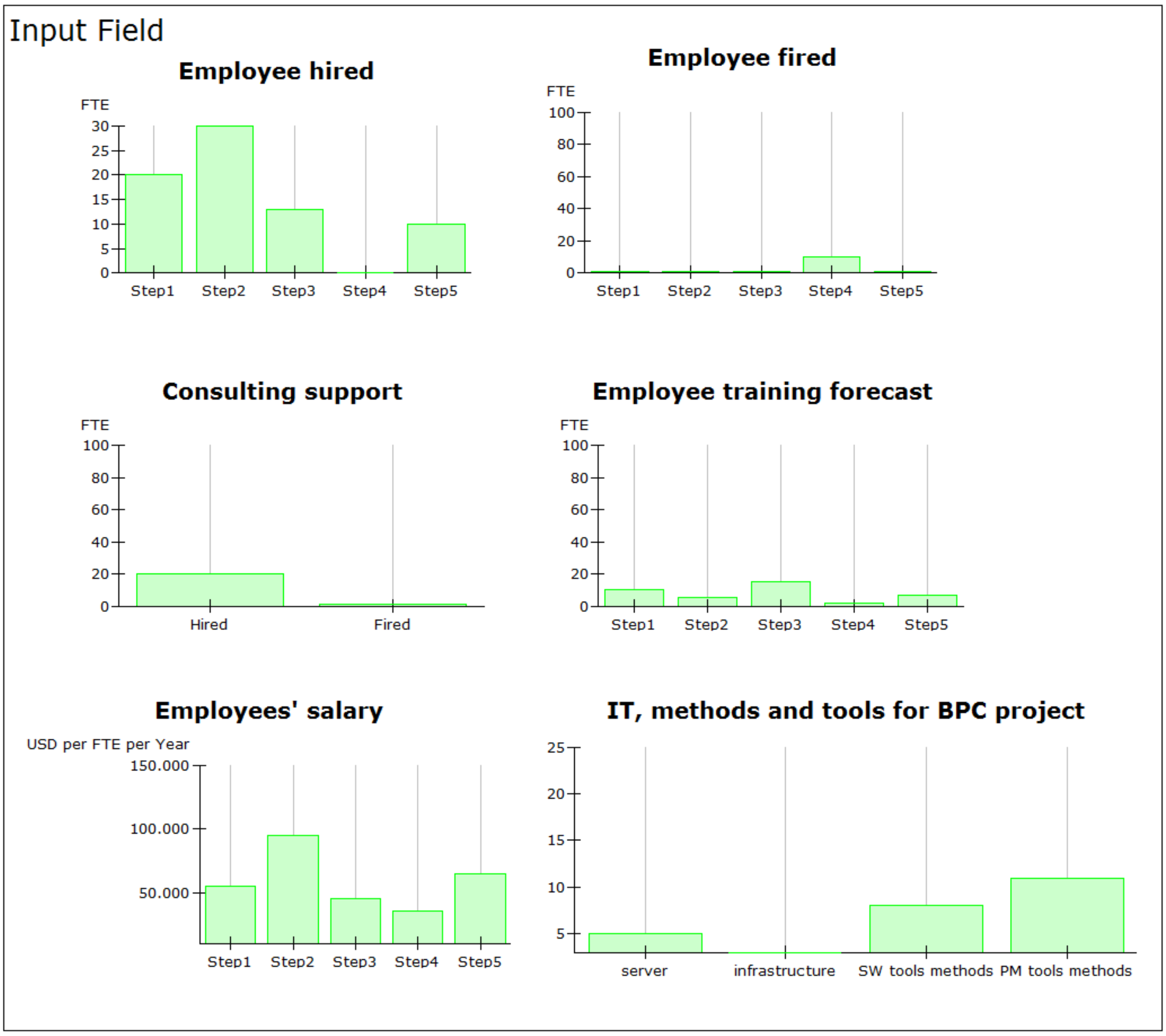


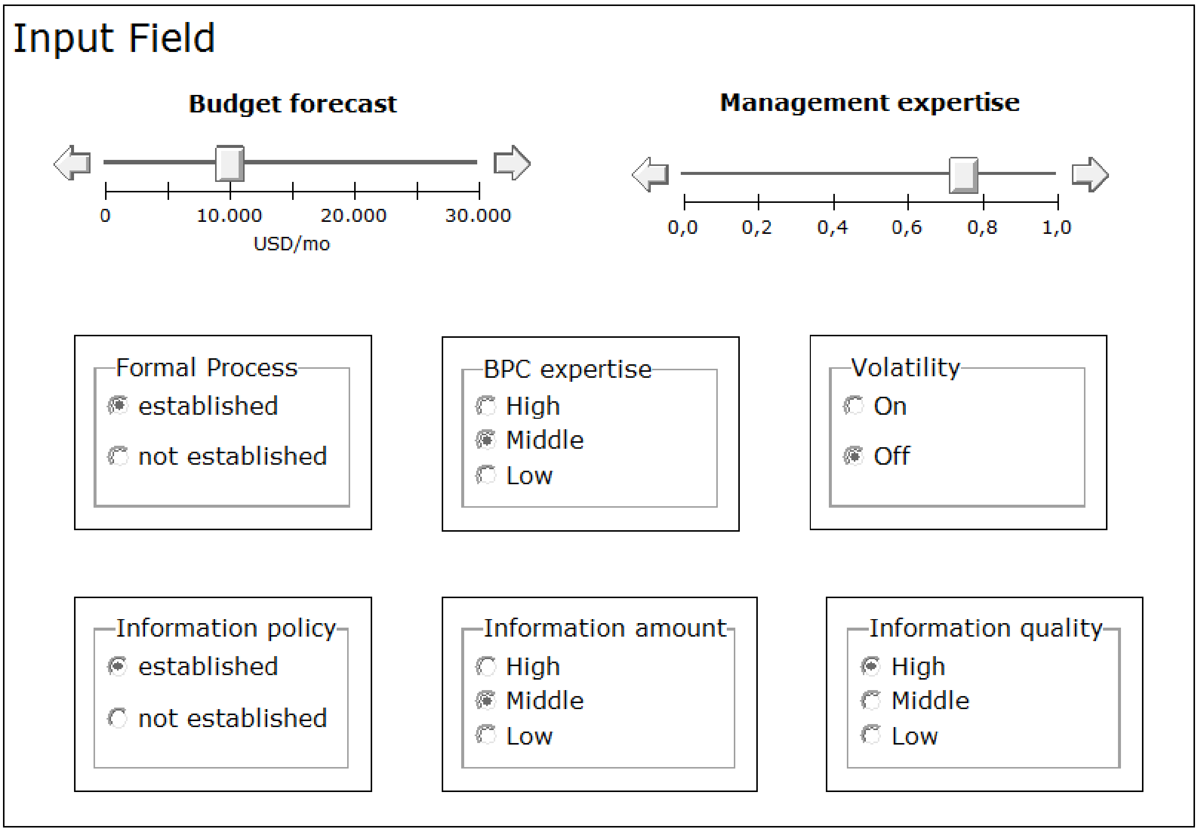
The model "IT performance and availability" shows the overall IT performance and its availability.

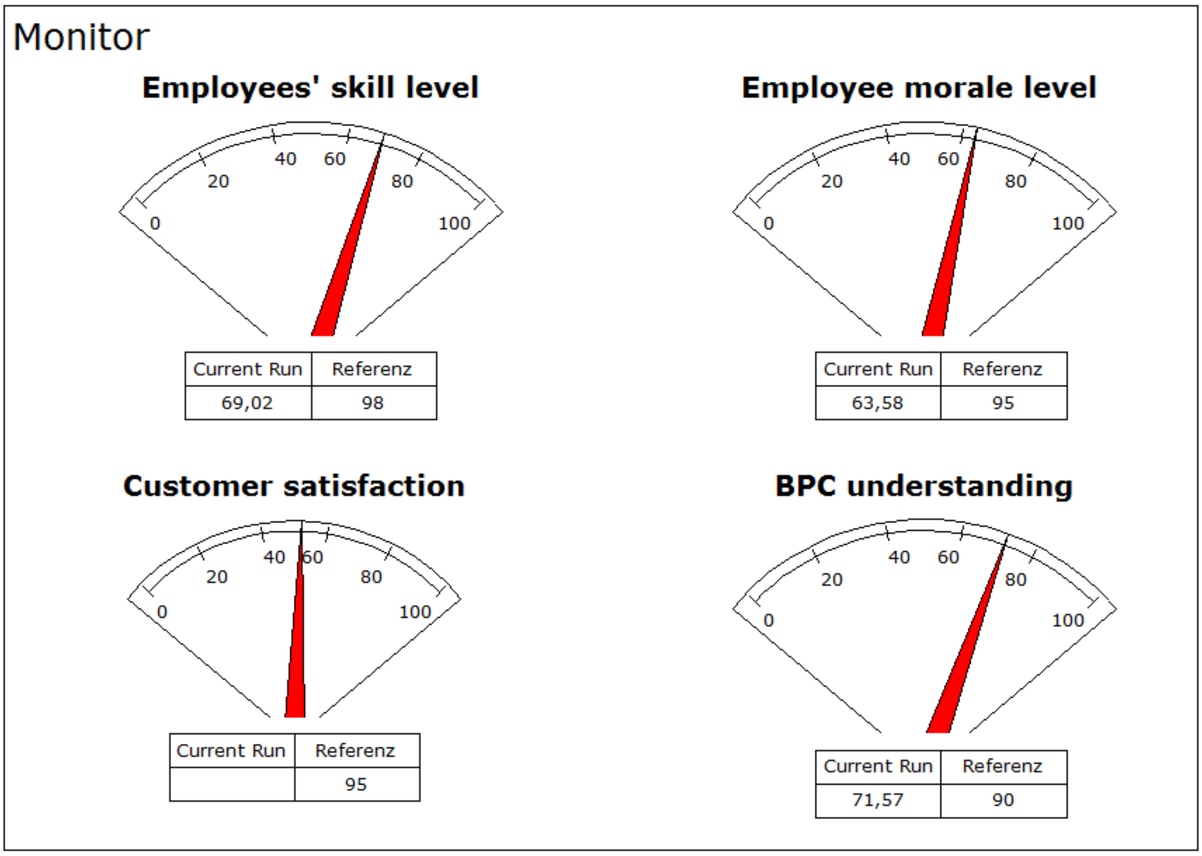


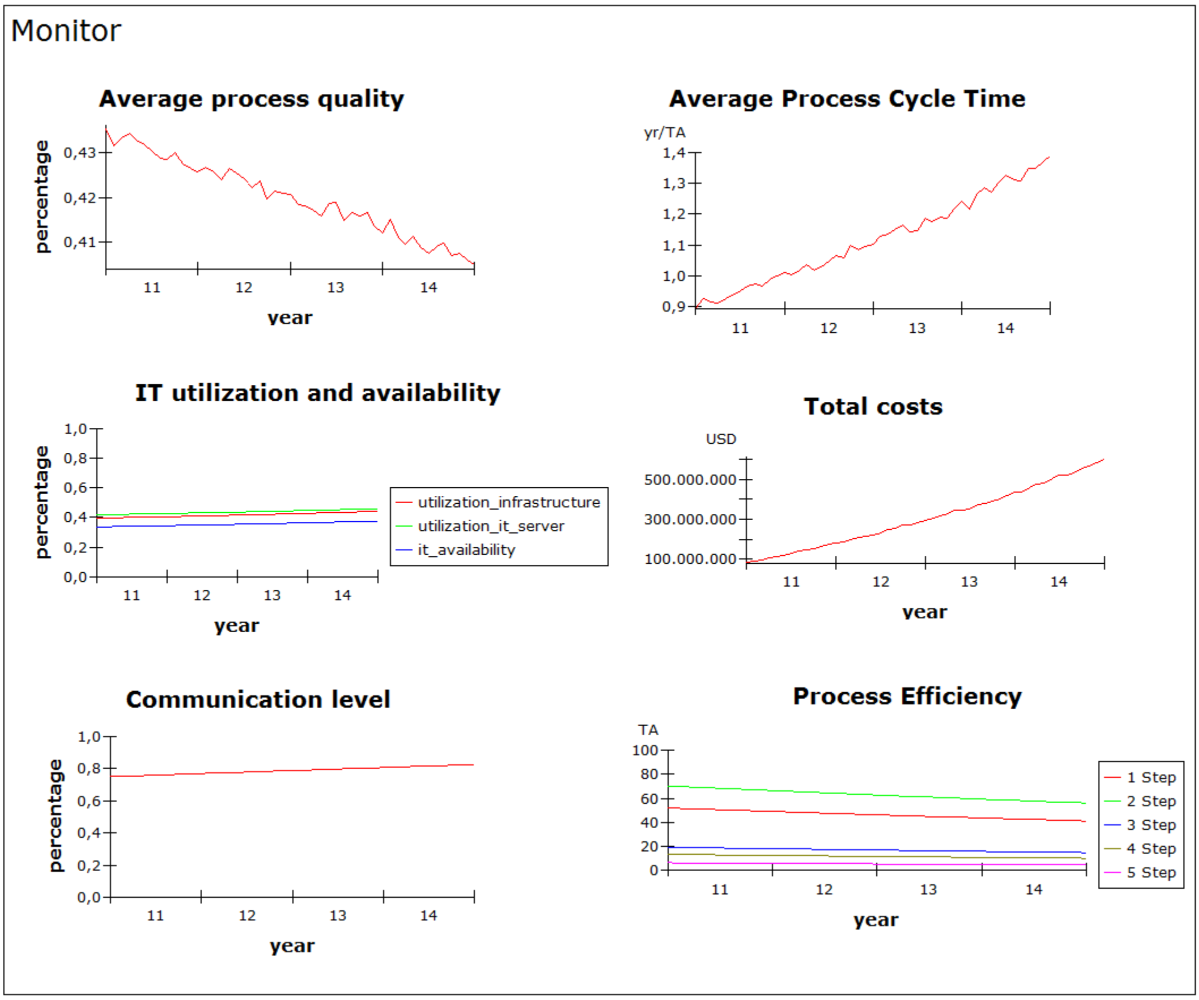
The model "IT Cost" displays the costs a company must spent to maintain the IT resources. The costs further cover the administrative costs of IT personnel.

To make the model a bit easier to experiment with, we have provided interactive elements to control some of the variables in the system. Buttons, sliders, gauges, radio buttons and diagrams make it easy to vary parameters and observe changes in the model behavior from run to run, without having to redefine variables.




Input Field
Budget forecast
0
10.000
20.000
30.000
USD/mo
Management expertise
0,0
0,2
0,4
0,6
0,8
1,0
Formal Process
established
not established
BPC expertise
High
Middle
Low
Volatility
On
Off
Information policy
established
not established
Information amount
High
Middle
Low
Information quality
High
Middle
Low


Monitor
Employees' skill level
0
20
40
60
80
100
Current Run
Referenz
69,02
98
Employee morale level
0
20
40
60
80
100
Current Run
Referenz
63,58
95
Customer satisfaction
0
20
40
60
80
100
Current Run
Referenz
95
BPC understanding
0
20
40
60
80
100
Current Run
Referenz
71,57
90


Monitor
Average process quality
percentage
0,43
0,42
0,41
11
12
13
14
year
Average Process Cycle Time
yr/TA
1,4
1,3
1,2
1,1
1,0
0,9
11
12
13
14
IT utilization and availability
percentage
1,0
0,8
0,6
0,4
0,2
0,0
11
12
13
14
year
utilization_infrastructure
utilization_it_server
it_availability
Total costs
USD
500.000.000
300.000.000
100.000.000
11
12
13
14
year
Communication level
percentage
1,0
0,8
0,6
0,4
0,2
0,0
11
12
13
14
year
Process Efficiency
TA
100
80
60
40
20
0
11
12
13
14
year
1 Step
2 Step
3 Step
4 Step
5 Step

Appendix B: Mathematical Formulas used in Simulation Model

In the following, we describe the mathematical formulas which are used in the proposed SD model presented in publication P6:

emp = INTEGRAL(emp_delta_in-emp_leaving;emp(t0))

emp_hired = INTEGRAL(emp_hired_reset;emp_hired(t0))

emp_fired =INTEGRAL(emp_fired_reset;emp_fired(t0))

emp_hired_reset = emp_hired

emp_fired_reset = emp_fired

emp_delta_in = MAX(0<<FTE>>;(emp_hired))

emp_leaving =

MIN((DIVZX(emp*emp_leaving_per_year;emp_morale;{1;1;1;1;1}<<FTE/yr>>)+(emp_fired/TIMESTEP));emp*1/TIMESTEP)

emp_total = arrsum(emp)

emp_leaving_per_year = is set to 0,01 1/yr

emp_ext_delta_in = MAX(0<<FTE>>;emp_ext_hired)

emp_ext_leaving = MIN(consulting_support_;MAX(0<<FTE>>;emp_ext_fired))

emp_ext_hired = INTEGRAL(emp_ext_hired_reset;emp_ext_hired(t0))

emp_ext_fired = INTEGRAL(emp_ext_fired_reset;emp_ext_fired(t0))

emp_ext_hired_reset = emp_ext_hired

emp_ext_fired_reset = emp_ext_fired

consulting_support = INTEGRAL(emp_ext_delta_in-emp_ext_leaving; consulting_support (t0))

emp_morale = INTEGRAL(emp_morale_increase-emp_morale_lost;emp_morale(t0))

emp_morale_increase = ((1 - (emp_morale))/time_to_return_to_normal)

time_to_return_to_normal = constant variable set to 3 months

emp_morale_lost =

IF(emp_morale<=0,05;0;(MIN(0,03;emp_morale*effect_of_change_understanding_on_emp_morale)))

emp_morale_total = ((ARRSUM(emp_morale))/5)*100

effect_of_change_understanding_on_emp_morale = IF(change_understanding>=0,75; -0,00023;0,013)

sl_emp = INTEGRAL(sl_emp_in-sl_emp_loss;sl_emp (t0))

sl_emp_in =

MIN(0,985;((DIVZX(sl_emp*emp+sl_emp_startwork*emp_delta_in;emp+emp_delta_in;{0;0

;0;0;0}))+((0,985-
sl_emp)*effect_of_BPC_experience_on_sl+effect_of_exchange_ideas_on_sl+effect_training
_on_sl)+0,0005))

sl_emp_loss = sl_emp

sl_emp_startwork = constant variable set to 0,7

effect_of_exchange_ideas_on_sl = ((1-exchange_ideas)/85)

effect_of_BPC_experience_on_sl = ((0,8-BPC_exp)/85)

change_understanding = INTEGRAL(change_understanding_increase-
change_understanding_decrease; change_understanding(t0))

change_understanding_increase =IF(change_understanding<=0,05;0;MAX(-0,03;((-
1*(effect_of_communication_on_change_understanding)*change_understanding))))

change_understanding_decrease=MIN(change_understanding;0)

effect_of_communication_on_chane_understanding = (0,75-communication)/38

communication = INTEGRAL(communication_in-communication_out;communication (t0))

communication_in = IF(time_of_communication>=2;-0,0082;
effect_information_quality_on_communication+effect_of_information_amount_on_communi
cation+effect_of_methods_tools_on_communication)

communication_out = MIN(communication;0)

effect_of_information_amount_on_communication = IF(information_amount >=0,75 AND
information_amount<=0,85;0,0045*information_amount;-0,0045*information_amount)

effect_information_qaulity_on_communication = IF(information_quality<=0,3;-0,025;(-
1)*0,01*(0,8-information_quality))

formal_process = INTEGRAL(formal_process_established-
formal_process_loss;formal_process (t0))

formal_process_established = MAX(BPC_exp;management_expertise)

formal_process_loss = IF(management_expertise<1;MIN(formal_process;0);formal_process)

emp_for_training =
(emp*avg_performance_emp)*time_spent_in_training_factor+(emp_ext_hired*avg_performa
nce_emp)*time_spent_in_training_factor+(emp_hired*avg_performance_emp_hired*time_sp
ent_in_training_factor*time_spent_in_training_factor)

total_emp_available_for_process = avg_performance_emp * emp +
avg_performance_emp_hired * emp_hired +emp_ext_hired*avg_performance_emp

emp_free_for_process_factor = (total_employee_available_for_proc-
emp_for_training)/(emp+emp_ext_hired+emp_hired)

avg_performance_emp_hired = is set to 0,3 constant variable → 1/3 of productivity

avg_performance_emp = is set to 1 constant variable

emp_training_forecast =
INTEGRAL(emp_training_forecast_reset;emp_training_forecast(t0))

costs_emp = emp*salary_emp+costs_emp_fired*emp_fired+costs_emp_hired*emp_hired

costs_ext = costs_ext_support*consulting_support_+costs_ext_support*emp_ext_hired

costs_total = ARRSUM(costs_emp)

salary_emp= INTEGRAL(salary_emp_in-salary_emp_out;salary_emp(t0))

salary_emp_increase= INTEGRAL(reset_salary_emp_increase; salary_emp_increase(t0))

salary_emp_decrease=INTEGRAL(reset_salary_emp_decrease;salary_emp_decrease(t0))

salary_emp_in = MAX(0<<USD/(FTE*yr)>>;salary_emp_increase)

salary_emp_out = MIN(salary_emp;MAX(0<<USD/(FTE*yr)>>;salary_emp_decrease))

costs_emp_hired_per_fte_delta =
MAX(0<<USD/(FTE*yr)>>;costs_emp_hired_per_fte_increase)

costs_emp_fired_per_fte_delta = MAX(0<<USD/(FTE*yr)>>;costs_fired_per_fte_increase)

costs_emp_hired_per_fte_increase =
INTEGRAL(costs_emp_hired_per_fte_reset;costs_emp_hired_per_fte_increase (t0))

costs_fired_per_fte_increase =
INTEGRAL(costs_emp_fired_per_fte_resetcosts_fired_per_fte_increase(t0))

costs_emp_hired_per_fte =
INTEGRAL(costs_emp_hired_per_fte_delta;costs_emp_hired_per_fte(t0))

costs_emp_fired_per_fte =
INTEGRAL(costs_emp_fired_per_fte_delta;costs_emp_hired_per_fte(t0))

costs_ext_support = INTEGRAL(costs_ext_delta_in;costs_ext_in (t0))

costs_ext_delta_in = MAX(0<<USD/(FTE*yr)>>;costs_ext_in)

proposals_to_be_processed = factor_transaction_function*factor_new_requests

proposals_processed =
MIN(proposals_to_be_processed/(proposals_to_be_processed+10<<TA/yr>>)*production_function[1]*1<<1/yr>>;proposals_to_be_processed)

proposals_success = proposals_processed*(1-error_rate[1])

proposals_to_be_approved = proposals_success

proposals_approved_processed =
MIN(proposals_to_be_approved/(proposals_to_be_approved+10<<TA/yr>>)*production_function[2]*1<<1/yr>>;proposals_to_be_approved)

proposals_approved_success = proposals_approved_processed*(1-error_rate[2])

customer_demand_to_be_checked_and_approved = proposals_approved_success

customer_demand_processed = MIN(customer_demand_to_be_checked_and_approved/(customer_demand_to_be_checked_and_approved+10<<TA/yr>>)*production_function[3]*1<<1/yr>>;customer_demand_to_be_checked_and_approved)

customer_demand_success = customer_demand_processed*(1-error_rate[3])

delivery_to_be_approved = customer_demand_success

delivery_approved_processed = MIN(delivery_to_be_approved/(delivery_to_be_approved+10<<TA/yr>>)*production_function[4]*1<<1/yr>>;delivery_to_be_approved)

delivery_approved_success = delivery_approved_processed*(1-error_rate[4])

invoice_and_bank_account_to_be_checked = delivery_approved_success

invoice_and_bank_account_checked_processed = MIN(invoice_and_bank_account_to_be_checked/(invoice_and_bank_account_to_be_checked+10<<TA/yr>>)*production_function[5]*1<<1/yr>>;invoice_and_bank_account_to_be_checked)

invoice_and_bank_account_checked_success = invoice_and_bank_account_checked_processed*(1-error_rate[5])

proposal_quality = DIVZX(proposals_success;proposals_to_be_processed;1)

proposal_approved_quality = DIVZX(proposals_approved_success;proposals_to_be_approved;1)

customer_demand_approved_quality = DIVZX(customer_demand_success;customer_demand_to_be_checked_and_approved;1)

delivery_approved_quality = DIVZX(delivery_approved_success;delivery_to_be_approved;1)

invoice_bank_account_approved_quality = DIVZX(invoice_and_bank_account_checked_success;invoice_and_bank_account_to_be_checked;1)

process_quality_avg = AVERAGE(customer_demand_approved_quality;delivery_approved_quality;invoice_bank_account_approved_quality;proposals_approved_quality;proposals_quality)

processing_time_proposals = DIVZX((2/9)*emp[1]*1<<1/FTE>>;proposals_success;0<<yr/TA>>)

processing_time:proposals_approved =
DIVZX((2/9)*emp[2]*1<<1/FTE>>;proposals_approved_success;0<<yr/TA>>)
processing_time_customer_demand =
DIVZX((2/9)*emp[3]*1<<1/FTE>>;customer_demand_success;0<<yr/TA>>)
processing_time_delivery =
DIVZX((2/9)*emp[4]*1<<1/FTE>>;delivery_approved_success;0<<yr/TA>>)
processing_time_invoice =
DIVZX((2/9)*emp[5]*1<<1/FTE>>;invoice_and_bank_account_checked_success;0<<yr/TA>>)
average_processing_time =
AVERAGE(processing_time_customer_demand;processing_time_delivery;processing_time_invoice;processing_time_proposals;processing_time_proposals_approved)
emp_efficiency = INTEGRAL(emp_efficiency_delta_in-emp_efficiency_delta_out;emp_efficiency (t0))
emp_efficiency_delta_in = IF(it_sw_methods_tools_performance<0,3;-0,03<<TA/FTE>>;MIN(60<<TA/FTE>>;((210<<TA/FTE>>-emp_efficiency)*(it_sw_methods_tools_performance/10))))
emp_efficiency_delta_out = emp_efficiency*0,05<<1/yr>>
production_function =
MIN(consulting_support_factor;project_manager_expertise_factor)*(sl_emp*(emp_efficiency*1<<FTE>>*it_availibility)*1*emp_free_for_process_factor)
proc_quality = INTEGRAL(proc_quality_in-proc_quality_loss;proc_quality(t0))
proc_quality_in = IF(process_quality_avg<=0,44;-0,003;(0,85-process_quality_avg)/30)+effect_sl_on_proc_quality+effect_emp_morale_on_proc_quality
proc_quality_loss = proc_quality_loss_delta*proc_quality
proc_quality_loss_delta = constant variable set to 0,001
error_rate = MAX((0,10-0,04*emp_morale-5*proc_quality/100)+process_volatility_impact;(0,10-0,04*sl_emp-5*proc_quality/100)+process_volatility_impact)
process_volatility = INTEGRAL(process_volatility_delta;process_volatility(t0))
random_process_volatility = RANDOM()
process_volatility_impact = random_process_volatility*process_volatility
customer_satisfaction = INTEGRAL(customer_satisfactoin_delta_in-customer_satisfaction_delta_out;customer_satisfaction (t0))

customer_satisfactoin_delta_in = (1-customer_satisfaction)/95

customer_satisfaction_delta_out = IF(customer_satisfaction<=0,05;0;(effect_quality_on_customer_sat*customer_satisfaction))

it_performance = INTEGRAL(it_performance_in-it_performance_out;it_performance (t0))

it_performance_in = IF(it_utilization>0,8;MAX(0,2;1-((it_utilization-0,8)^(1,2)));1)

it_performance_out = it_performance

it_utilization = MAX(utilization_infrastructure;utilization_it_server)

it_availability = MAX(0;MIN(1;it_performance*it_age))

it_age = constant variable

it_server = INTEGRAL(it_server_in-it_server_out;it_server(t0))

it_server_new = INTEGRAL(it_server_new_reset;it_server_new(t0))

it_server_scrap = INTEGRAL(it_server_scrap_reset;it_server_scrap(t0))

it_server_in = MAX(0<<MIPS>>;it_server_new)

it_server_out = MIN(it_server;MAX(0<<MIPS>>;it_server_scrap))

it_server_interruption = MIN(it_server*(1/12)*1<<1/yr>>; it_server*(interruptions+0,02<<1/yr>>*(age_of_server/7<<yr>>)))

interruptions = constant set to 0,001

age_of_server = INTEGRAL(age_of_server_in-age_of_server_out;age_of_server(t0))

age_of_server_in = DIVZX((age_of_server*it_server+0<<yr>>*it_server_in);(it_server+it_server_in);0<<yr>>)+ TIMESTEP

age_of_server_out = age_of_server

utilization_it_server = DIVZX(it_server_required_norm;it_server;1)

it_infrastructure = INTEGRAL(it_infrastructure_in-it_infrastructure_out;it_infrastructure (t0))

it_infrastructure_new = INTEGRAL(it_infrastructure_new_reset;it_infrastructure_new(t0))

it_infrastructure_scrap = INTEGRAL(it_infrastructure_scrap_reset; it_infrastructure_scrap (t0))

it_infrastructure_in = MAX(0<<TBmo>>;it_infrastructure_new)

it_infrastructure_out = MIN(it_infrastructure;MAX(0<<TBmo>>;it_infrastructure_scrap))

it_infrastructure_interruption = MIN(it_infrastructure*(1/12)*1<<1/yr>>;it_infrastructure*(interuptions/1<<yr>>+0,02<<1/yr >>*(age_of_it_infrastructre/7<<yr>>)))

age_of_infrastructure = INTEGRAL(age_of_infrastructure_in-age_of_infrastructure_out;age_of_infrastructure(t0))

age_of_infrastructure_in = (DIVZX((age_of_it_infrastructre*it_infrastructure+0<<yr>>*it_infrastructure_in);(it_infrastructure+it_infrastructure_in);0<<yr>>))+TIMESTEP

age_of_infrastructure_out = age_of_it_infrastructure

utilization_infrastructure = DIVZX(it_infrastructure_required_norm;it_infrastructure;1)

it_sw_methods_tools = INTEGRAL(it_sw_methods_tools_delta_in-it_sw_methods_tools_delta_out;it_sw_methods_tools (t0))

it_sw_methods_tools_new = INTEGRAL(it_sw_methods_tools_new _reset; it_sw_methods_tools_new(t0))

it_sw_methods_tools_scrap = INTEGRAL(it_sw_methods_tools_scrap _reset; it_sw_methods_tools_scrap(t0))

it_sw_methods_tools_delta_in = MAX(0<<LI>>;it_sw_methods_tools_new)

it_sw_methods_tools_delta_out = MIN(it_sw_methods_tools;MAX(0<<LI>>;it_sw_methods_tools_scrap))

it_sw_methods_tools_it = it_sw_methods_tools-(emp*5<<LI/FTE>>)

it_sw_methods_tools_new_sum = ARRSUM(it_sw_methods_tools_new)

it_sw_methods_tools_performance = (MIN(it_sw_methods_tools_it/emp;5<<LI/FTE>>)/5<<LI/FTE>>)

it_sw_methods_tools_total = ARRSUM(it_sw_methods_tools)

costs_per_it_servver = 1000<<USD>>

number_of_it_server = it_server+it_server_in

costs_it_server = costs_per_it_server*number_of_it_server

costs_it_server_maintanance_in = costs_it_server*costs_per_maintanance

costs_it_server_maintanance = costs_it_server_maintanance_in

costs_per_maintanance = constant

costs_per_it_infrastructure = 850<<USD>>

number_of_it_infrastructure_equipment = it_infrastructure+it_infrastructure_in

costs_it_infrastructure = costs_per_it_infrastructure*number_of_it_infrastructure_equipment

costs_it_infrastructure_maintanance_in = costs_it_infrastructure*costs_per_maintanance

costs_it_infrastructure_maintanance = costs_it_infrastructure_maintanance_in costs_it_administration_delta_in = (number_of_it_server/server_per_admin+number_of_it_infrastructure_equipment/infrastructure_per_admin)*costs_per_admin

costs_it_administration = costs_it_administration_delta_in

infrastructure_per_admin = 4000<<TBmo/FTE>>

server_per_admin = 30000<<MIPS/FTE>>

costs_per_admin = 45000<<USD per FTE per Year>>

costs_it_sw_methods_tools = costs_per_sw_methods_tools*ARRSUM(it_sw_methods_tools)+costs_per_sw_methods_tools*ARRSUM(it_sw_methods_tools_new)

costs_it_investment_total = costs_it_infrastructure/1<<TBmo>>+costs_it_server/1<<MIPS>>+costs_it_sw_methods_tools/1<<LI>>

costs_it_operating_total = costs_it_administration*1<<yr>>+costs_it_infrastructure_maintanance/1<<TBmo>>+costs_it_server_maintanance/1<<MIPS>>

total_costs = (costs_it_total/1<<yr>>+costs_total_employee_resources)*cycle_time_effect

margin_balance = INTEGRAL (margin_borrow_delta_in –(margin_payoff +margin_borrow_interest);margin_balance(t0))

margin_borrow_delta_in = margin_borrow/1<<da>>

margin_payoff = IF(margin_balance > payoff_amount; payoff_amount/1<<da>>; (margin_balance/1<<da>>) + margin_borrow_interest)

margin_borrow_interest = margin_balance*interest_rate

margin_borrow = INTEGRAL(margin_borrow_reset;margin_borrow(t0))

interest_rate = constant set to 0,4<<1/yr>>

payoff_amount = IF(margin_payoff_decided > available_budget*1<<USD>>; available_budget*1<<USD>>; margin_payoff_decided)

margin_payoff_decide = INTEGRAL(payoff_reset;margin_payoff_decide(t0))

payoff_reset = margin_payoff_decided

margin_borrow_reset = margin_borrow

available_budget = budget_size_forecast/1<<USD>>-(costs_it_total/1<<USD>>+costs_total_employee_resources/1<<USD>>*1<<yr>>)