A System Dynamics Model for Business Process Change Projects

Zuzana Rosenberg, Tobias Riasanow, Helmut Krcmar
Technische Universität München
Chair of Information Systems
Boltzmannstr. 3
Garching b. München, Germany
zuzana.rosenberg|tobias.riasanow|krcmar@in.tum.de

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.

Keywords: Business process change, system dynamics, simulation model, meta-case analysis

1. Introduction

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 et al., 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, 1990; 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 2, we provide an overview of BPC and review the application of SD in BPC and adjacent areas. In section 3, we describe the process and problem statement, and we explain our SD simulation model. In section 4, we demonstrate the use of the SD model by simulating various decisions. We discuss our results and limitations in section 5 and present our conclusions in section 6.

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.

2.1 Business Process Change

BPC was initially proposed by Grover & Kettinger (1995), and the concept was subsequently enhanced by Grover & Kettinger (1997) and Kettinger et al. (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 (BPR; Grover et al., 2000; Grover & Markus, 2008; Sarker et al., 2006), as presented in Figure 1.

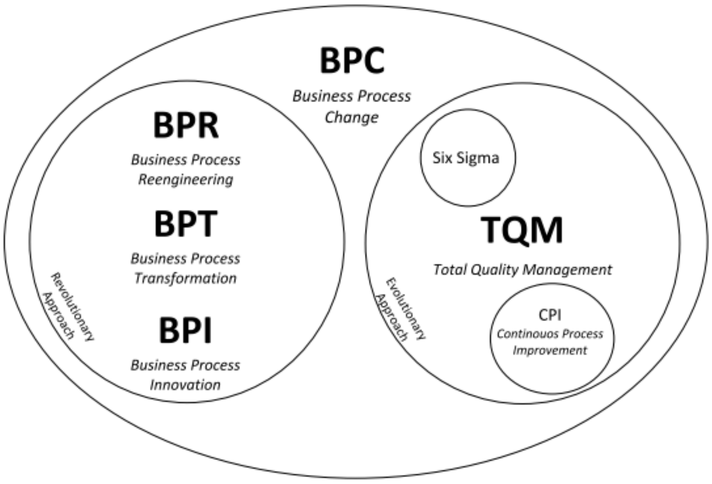


Figure 1 - Central elements of BPC

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. (2012), 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 & 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 et al., 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 et al., 2000). Grover et al. (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 et al. (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 et al. (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 (i.e., Grover, 1999; Guha et al., 1997; Jurisch et al., 2012; Jurisch et al., 2013; Kettinger & Grover, 1995; Melville et al., 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 (i.e., 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 et al., 2004). The first model developed to conduct BPC projects in organizations was first introduced in 1995 by Kettinger & Grover and later presented in their MISQ article (Kettinger et al., 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 et al., 1997). The framework of Kettinger & 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 & 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 et al., 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 et al., 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 & Grover (1995). Although Kettinger & 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 et al. (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 et al., 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).

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 1 shows an overview of the identified SD publications in BPC and adjacent research areas.

Table 1 - Application areas of SD publications

Application area	**Sources**
Change management	Cooper & Reichelt (2004); Eden et al. (1998); Howick & Eden (2001); Howick (2003)
Supply chain management	Akkermans & Dellaert (2005); Anderson et al. (2005); Spengler & Schroeter (2003)
Project management	Lyneis et al. (2001); Park & Pena-Mora (2003); Taylor & Ford (2006)
BPC	Ashayeri et al. (1998); Baguma & Ssewanyana (2008); Burgess (1998); Kristekova et al. (2012); van Ackere et al. (1993)

The target of applying SD to change management practices is primarily to study the effects of disruption and delay (D&D) (e.g., Cooper & Reichelt, 2004; Eden et al., 1998; Howick & Eden, 2001; Howick, 2003). Cooper & 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 & 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 et al., 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 et al., 2001; Park & Pena-Mora, 2003; Taylor & Ford, 2006). Lyneis et al. (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 et al., 1998; Baguma & Ssewanyana, 2008; Burgess, 1998; Kristekova et al., 2012; van Ackere et al., 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 et al., 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 et al. (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.

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.

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 2). 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.

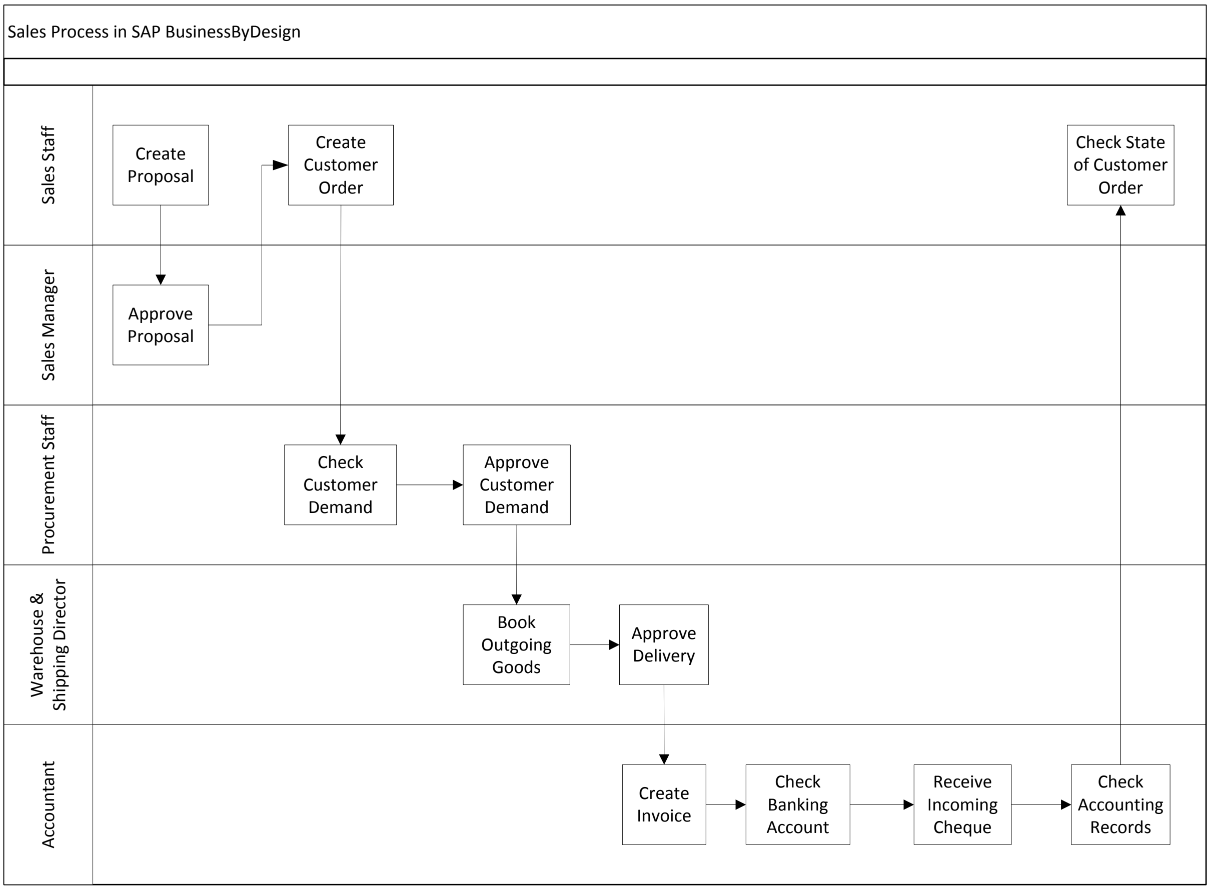


Figure 2 - Sales process in SAP business by design

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 3.

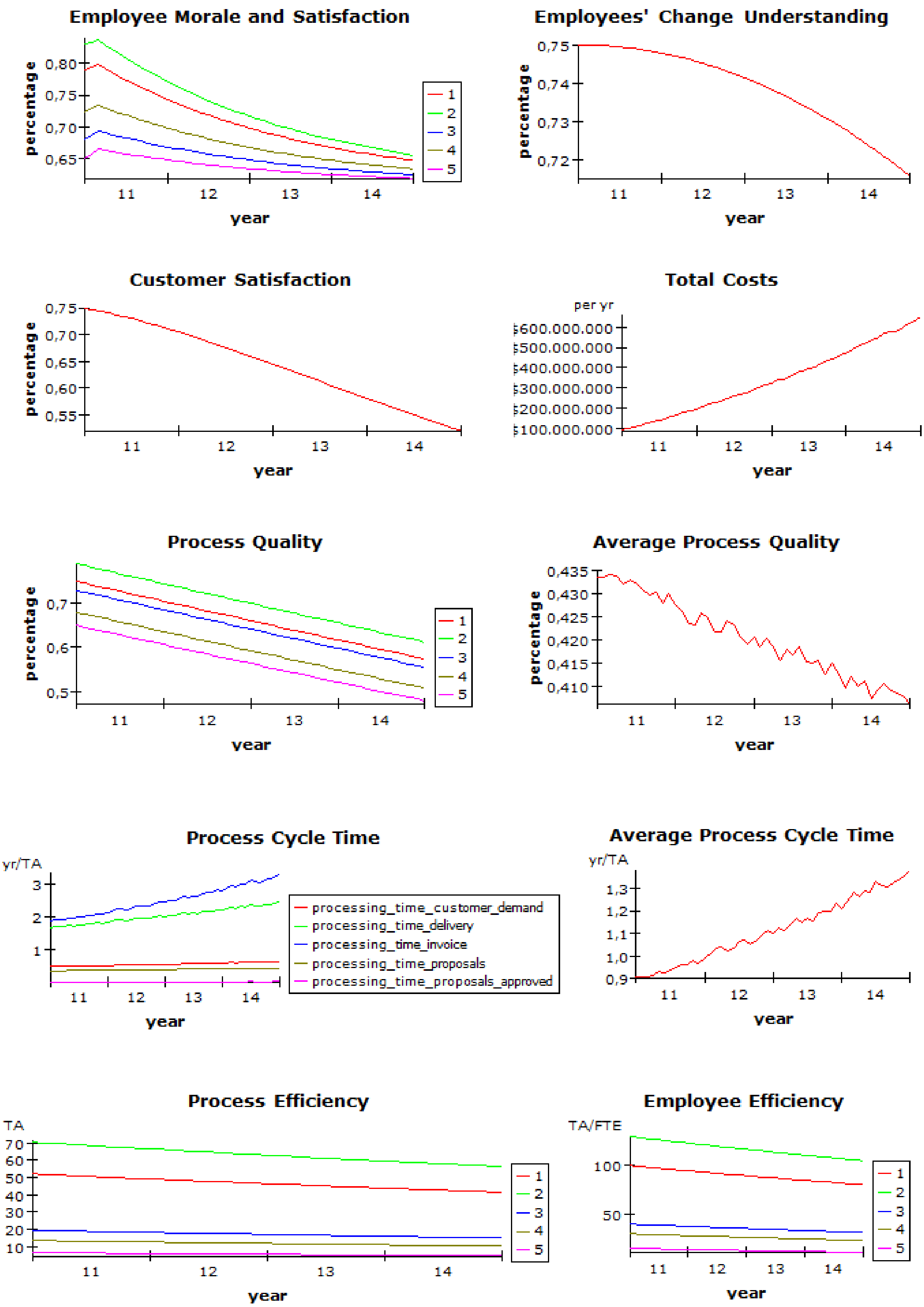


Figure 3 - Current situation in the sales process

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.

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.

4. Simulation Results

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

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 4).

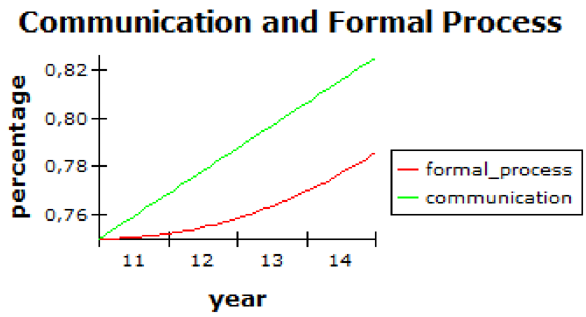


Figure 4 - Simulation results for communication and formal process

Figure 5 shows the positive effect of established formal process and effective communication on employees' understanding of change and employee morale.

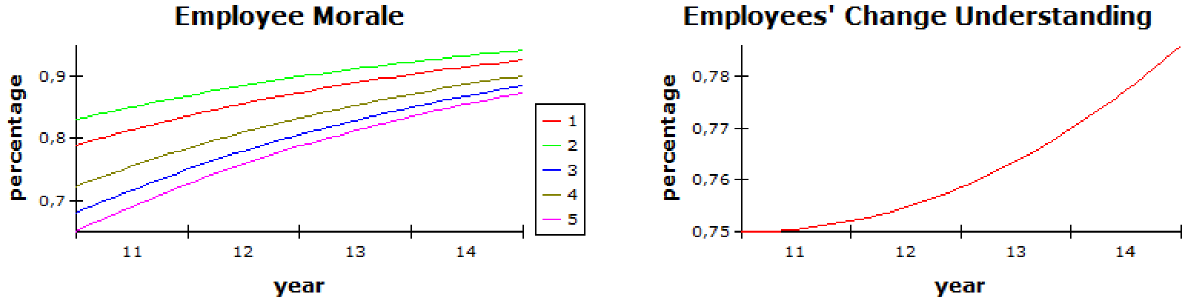


Figure 5 - Simulation results for employee morale and employees' understanding of change

4.2 Improvement in Employee 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 6 shows the positive effect of training, cooperation and the idea exchange program on employees' skill level.

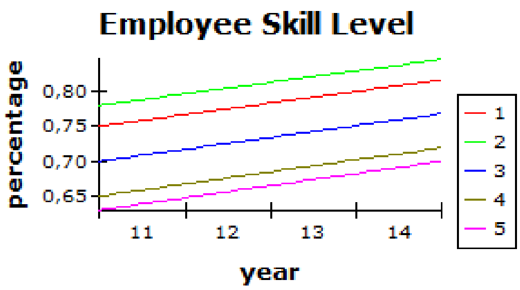


Figure 6 - Simulation results for employee skill level

Higher employee skill levels have a positive effect on the overall process quality (see Figure 7), and improvements in the overall process quality leads to higher customer satisfaction (see Figure 8).

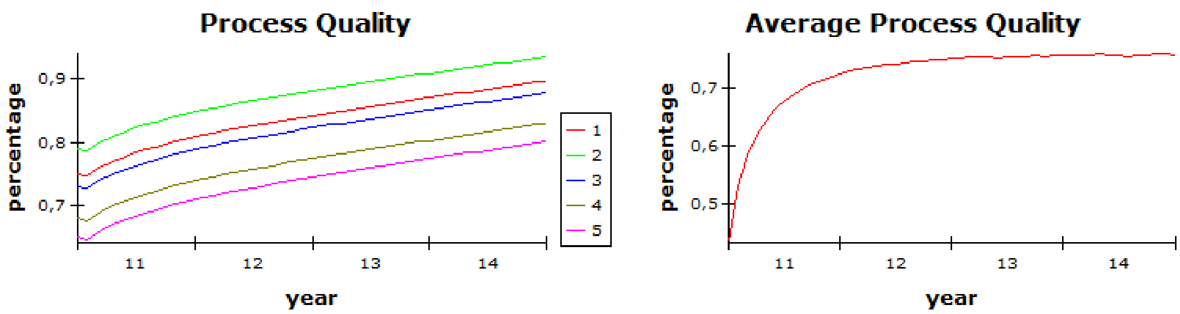


Figure 7 - Simulation results for process quality

Figure 8 - Simulation results for customer satisfaction

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 **9** shows the positive effect of the employed SW tools and methods on employee efficiency.

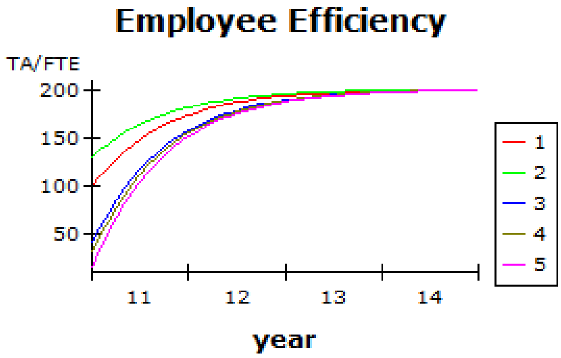


Figure 9 - Simulation results for employee efficiency

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 10 shows the overall process efficiency.

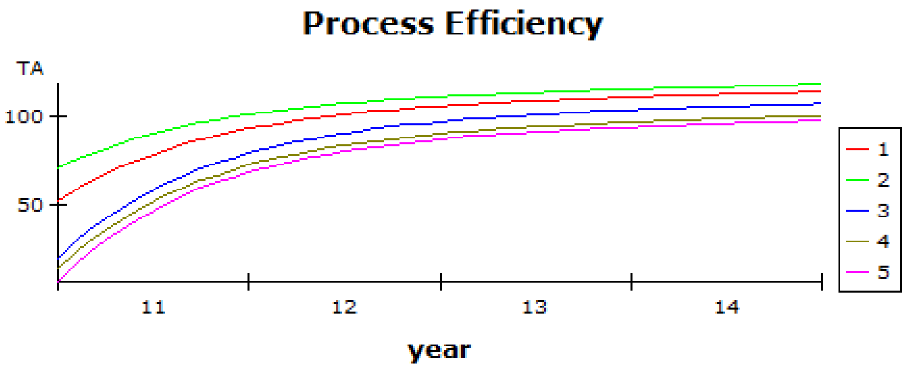


Figure 10 - Simulation results for process efficiency

The overall process efficiency increased in each process step. The higher process efficiency indicates lower processing times (see Figure 11) and a higher number of processed transactions (see Figure 12).

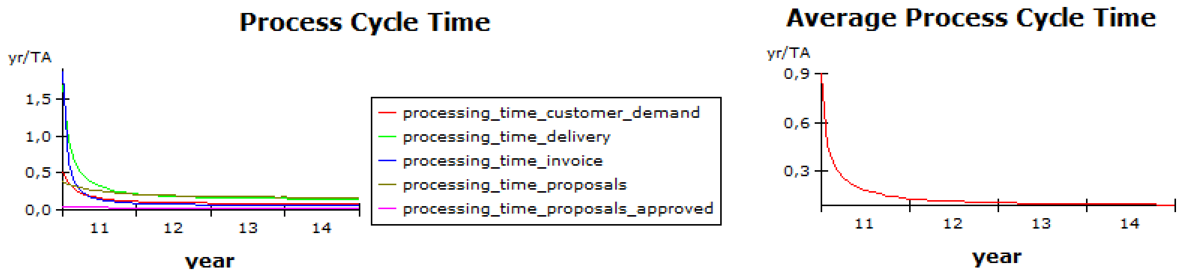


Figure 11 - Simulation results for process cycle time

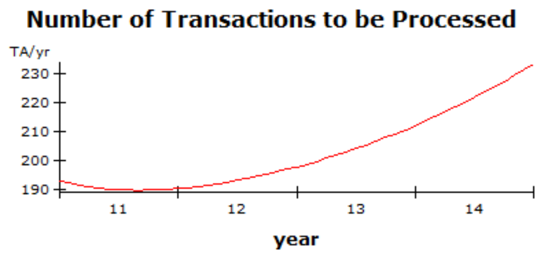


Figure 12 - Simulation results for the number of transactions to be processed

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.

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.

References

Akkermans, H., & Dellaert, N. (2005). The Rediscovery of Industrial Dynamics: The Contribution of System Dynamics to Supply Chain Management in a Dynamic and Fragmented World. *System Dynamics Review*, *21*(3), 173–186.

Anderson, E. G. J., Morrice, D. J., & Lundeen, G. (2005). The "physics" of Capacity and Backlog Management in Service and Custom Manufacturing Supply Chains. *System Dynamics Review*, *21*(3), 217–247.

Ashayeri, J., Keij, R., & Broeker, A. (1998). A Global Business Process Re-engineering: A System Dynamics-based Approach. *International Journal of Operations & Production Management*, *18*(9/10), 817–831.

Baguma, I., & Ssewanyana, J. K. (2008). A Simulation Modelling-based Investigation of the Impact of IT Infrastructure on Business Process Reengineering. *Journal of Computing and ICT Research*, *1*(1), 8–20.

Ben-Zvi, T. (2010). The Efficacy of Business Simulation Games in Creating Decision Support Systems: An Experimental Investigation. *Decision Support Systems*, *49*(1), 61–69.

Burgess, T. F. (1998). Modelling the Impact of Reengineering with System Dynamics. *International Journal of Operations & Production Management*, *18*(9/10), 950–963.

Cao, G., Clarke, S., & Lehaney, B. (2001). A Critique of BPR from a Holistic Perspective. *Business Process Management Journal*, *7*(4), 333–339.

Cooper, K. G., & Reichelt, K. S. (2004). Project Changes: Sources, Impacts, Mitigation, Pricing, Ligitation, and Excellence. In P. W. G. Morris & J. K. Pinto (Eds.), *The Wiley Guide to Managing Projects* (pp. 743–772). Hoboken, NJ: Wiley.

Crosby, P. B. (1979). *Quality is Free*. New York, NY: New American Library.

Dale, B. G. (1994). TQM: An Overview. In D. G. Dale, R. J. Boaden, & D. Lascelles (Eds.), *Managing Quality* (2nd ed., pp. 3–33). Herts, UK: Prentice Hall International.

Davenport, T. H., & Stoddard, D. B. (1994). Reengineering: Business Change of Mythic Proportions? *MIS Quarterly*, *18*(2), 121–127.

Deming, W. E. (1981). Improvement of Quality and Productivity through Action by Management. *National Productivity Review*, *1*(1), 12–22.

Deming, W. E. (1982). *Quality, Productivity and Competitive Position*. Cambridge, MA: MIT Center for Advanced Engineering.

Deming, W. E. (1986). *Out of the Crisis*. Cambridge, MA: MIT Center for Advanced Engineering.

Eden, C. E., Williams, T. M., & Ackermann, F. A. (1998). Dismantling the Learning Curve: The Role of Disruptions on the Planning of Development Projects. *International Journal of Project Management*, *16*(3), 131–138.

Flood, R. L., & Jackson, M. C. (1991). Total Systems Intervention: A Practical Face to Critical Systems Thinking. *System Practice*, *4*(3), 197–213.

Forrester, J. W. (1961). *Industrial Dynamics*. Cambridge, MA: The MIT Press.

Forrester, J. W. (1976). Educational Implications of Responses to System Dynamics Models. In C. W. Churchman & R. O. Mason (Eds.), *World Modeling: A Dialogue* (2nd ed., pp. 27–35). New York, NY: American Elsevier.

Forrester, J. W. (1985). "The" Model versus a Modeling "process." *System Dynamics Review*, *1*(1), 133–134.

Forrester, J. W. (1992). Policies, Decisions, and Information Sources for Modeling. *European Journal of Operational Research*, *59*(1), 42–53.

Grover, V. (1999). From Business Reengineering to Business Process Change Management: A Longitudinal Study of Trends and Practices. *IEEE Transactions on Engineering Management*, *46*(1), 36–46.

Grover, V., & Kettinger, W. J. (1995). *Business Process Change: Reengineering Concepts, Methods, and Technologies* (p. 704). Harrisburg, PA: Idea Group Publishing.

Grover, V., & Kettinger, W. J. (1997). Special Section: The Impact of Business Process Change on Organizational Performance. *Journal of Management Information Systems*, *14*(1), 9–12.

Grover, V., Kettinger, W. J., & Teng, J. T. . (2000). Business Process Change in the 21st Century. *Business & Economic Review*, *46*(2), 14–18.

Grover, V., & Markus, L. (2008). *Business Process Transformation*. Armonk, NY: M.E. Sharpe.

Guha, S., Grover, V., Kettinger, W. J., & Teng, J. T. C. (1997). Business Process Change and Organizational Performance: Exploring an Antecedent Model. *Journal of Management Information Systems*, *14*(1), 119–154.

Hammer, M., & Champy, J. (1993). *Reengineering the Corporation - A Manifesto for Business Revolution*. New York, NY: HarperCollins.

Hlupic, V., & de Vreede, G. (2005). Business Process Modelling using Discrete-Event Simulation: Current Opportunities and Future Challenges. *International Journal of Simulation and Process Modelling*, *1*(1-2), 72–81.

Howick, S. (2003). Using System Dynamics to Analyze Disruption and Delay in Complex Projects for Litigation: Can the Modelling Purposes Be Met? *The Journal of the Operational Research Society*, *54*(3), 222–229.

Howick, S., & Eden, C. (2001). The Impact of Disruption and Delay when Compressing Large Projects: Going for Incentives? *Journal of the Operational Research Society*, *52*(1), 26–34.
Ishikawa, K. (1976). *Guide to Quality Control*. Tokyo, Japan: Asian Productivity Organization.
Juran, J. M. (1974). *Quality Control Handbook*. *Industrial Quality Control*. New York, NY: McGraw Hill.
Juran, J. M. (1992). *Juran on Quality By Design*. New York, NY: Free Press.
Juran, J. M., & Gryna, F. M. (Eds. . (1988). *The Quality Control Handbook*. New York, NY: McGraw Hill.
Jurisch, M. C. (2014). *IT-enabled Business Process Change in Private and Public Sector Organizations*. Dissertation, Technische Universität München.
Jurisch, M. C., Cuno, J., Palka, W., Wolf, P., & Krcmar, H. (2012). An Integrative Model of IT-Enabled Business Process Change: Causal Structures in Theory, Research and Practice. In *Hawaii International Conference on System Services* (pp. 4297–4306).
Jurisch, M. C., Ikas, C., Wolf, P., & Krcmar, H. (2013). Key Differences of Private and Public Sector Business Process Change. *e-Service Journal*, *9*(1), 3–27.
Kettinger, W. J., & Grover, V. (1995). Special Section: Toward a Theory of Business Process Change Management. *Journal of Management Information Systems*, *12*(1), 9–30.
Kettinger, W. J., Teng, J. T. C., & Guha, S. (1997). Business Process Change: A Study of Methodologies, Techniques, and Tools. *MIS Quarterly*, *21*(1), 55–80.
Kliem, R. L. (2000). Risk Management for Business Process Reengineering Projects. *Information Systems Management*, *17*(4), 66–68.
Konstantidinis, C., Kienegger, H., Flormann, L., Wittges, H., & Krcmar, H. (2012). *SAP Business ByDesign - Anpassung und Integration*. SAP PRESS.
Kristekova, Z., Jurisch, M. C., Schermann, M., & Krcmar, H. (2012). Consolidating Findings from Business Process Change Case Studies Using System Dynamics: The Example of Employee Morale. *Knowledge Management & E-Learning: An International Journal (KM&EL)*, *4*(4), 455–480.
Lyneis, J. ., Cooper, K. G., & Els, S. A. (2001). Strategic Management of Complex Projects: A Case Study using System Dynamics. *System Dynamics Review*, *17*(3), 237–260.
Madachy, R. J. (2008). *Software Process Dynamics*. Hoboken, NJ: John Wiley & Sons.
Margherita, A., & Petti, C. (2010). ICT-enabled and Process-based Change: An Integrative Roadmap. *Business Process Management Journal*, *16*(3), 473–491.
Melville, N., Kraemer, K. L., & Gurbaxani, V. (2004). Information Technology and Organizational Performance: An Integrative Model of IT Business Value. *MIS Quarterly*, *28*(2), 283–322.
Park, M., & Pena-Mora, F. (2003). Dynamic Change Management for Construction: Introducing the Change Cycle into model-based Project Management. *System Dynamics Review*, *19*(3), 213–242.
Powell, T. C. (1995). Total Quality Management as Competitive Advantage: A Review and Empirical Study. *Strategic Management Journal*, *16*(1), 15–37.
Rosenberg, Z., Jurisch, M., Schermann, M., & Krcmar, H. (2014) Using Case Survey Methodology to Extract Variables and Causal Links: An Example from Studying Business Process Change. Proceedings of the 32nd International Conference of the System Dynamics Society, Wiley, Delft, Netherlands.
Sarker, S., Sarker, S., & Sidorova, A. (2006). Understanding Business Process Change Failure: An Actor-Network Perspective. *Journal of Management Information Systems*, *23*(1), 51–86.
Senge, P. M. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York, NY: Currency Doubleday.
Spector, J. M., & Davidsen, P. I. (1997). Creating Engaging Courseware Using System Dynamics. *Computers in Human Behavior*, *13*(2), 127–155.
Spengler, T., & Schroeter, M. (2003). Strategic Management of Spare Parts in closed-loop Supply Chains—A System Dynamics Approach. *Interfaces*, *33*(6), 7–17.
Strebel, P. (1996). Why Do People Resist Change? *Harvad Business Review*, *74*(3), 86–92.
Suarez, J. G. (1992). *Three Experts on Quality Management: Phillip B. Crosby, W. Edwards Deming, & Joseph M. Juran*. Arlington, VA: Department of the Navy Total Quality Leadership Office.

Taylor, T., & Ford, D. N. (2006). Tipping Point Dynamics in Development Projects. *System Dynamics Review*, *22*(1), 51–71.

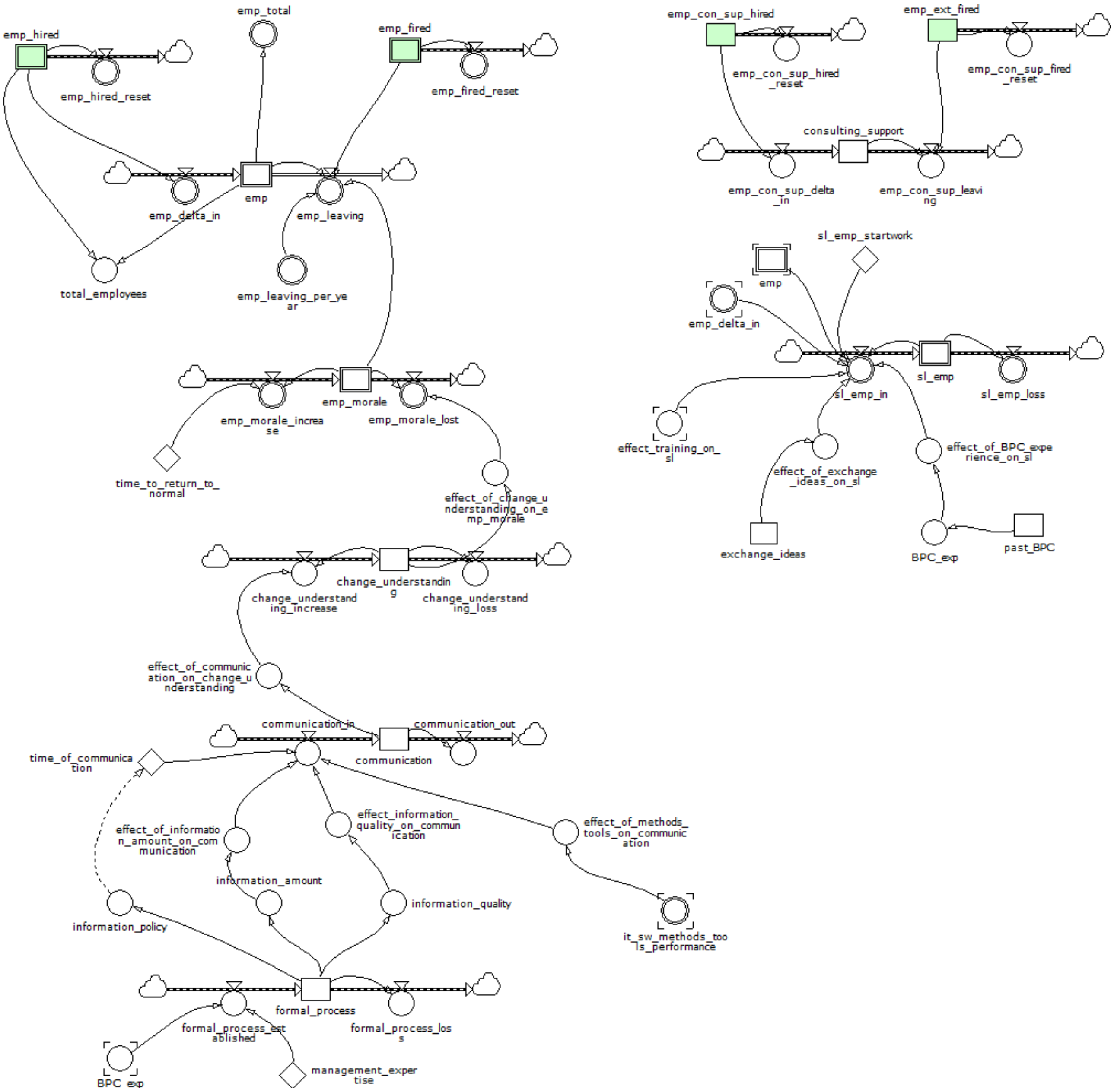
Trkman, P. (2010). The Critical Success Factors of Business Process Management. *International Journal of Information Management*, *30*(2), 125–134.

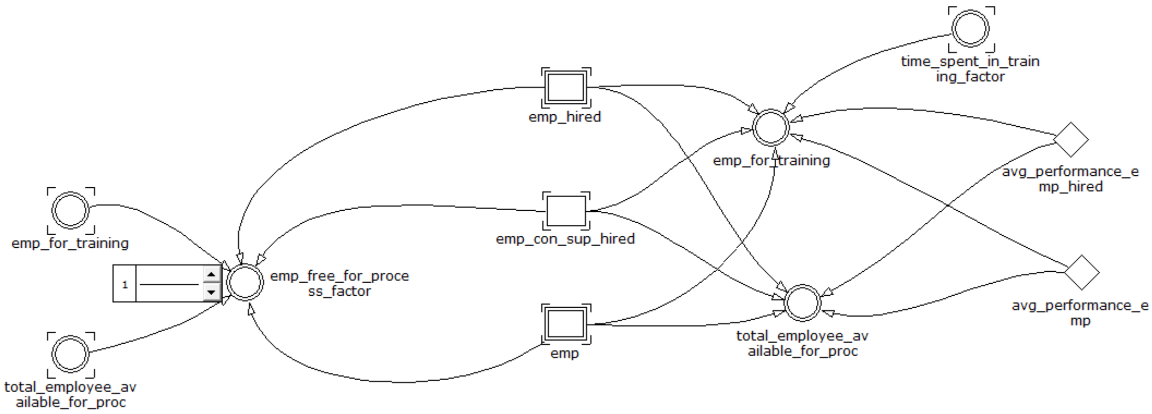
VanAckere, A., Larsen, E. R., & Morecroft, J. D. W. (1993). Systems Thinking and Business Process Redesign: An Application to the Beer Game. *European Management Journal*, *11*(4), 412–423.

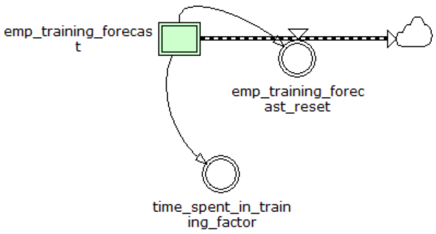
Vergidis, K., Tiwari, A., & Majeed, B. (2006). Business Process Improvement using Multi-objective Optimization. *BT Technology Journal*, *24*(2), 229–242.

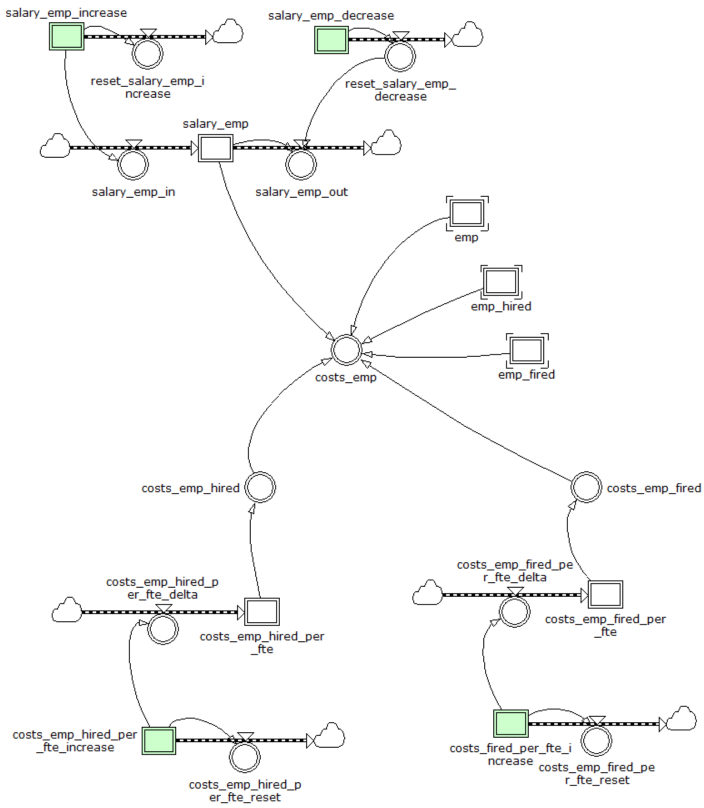
Xirogiannis, G., & Glykas, M. (2004). Fuzzy Cognitive Maps in Business Analysis and Performance - Driven Change. *IEEE Transactions on Engineering Management*, *51*(3), 334–351.

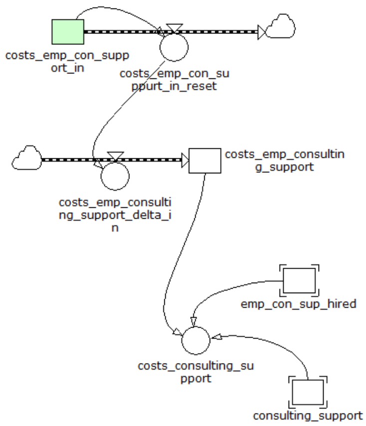
Appendix

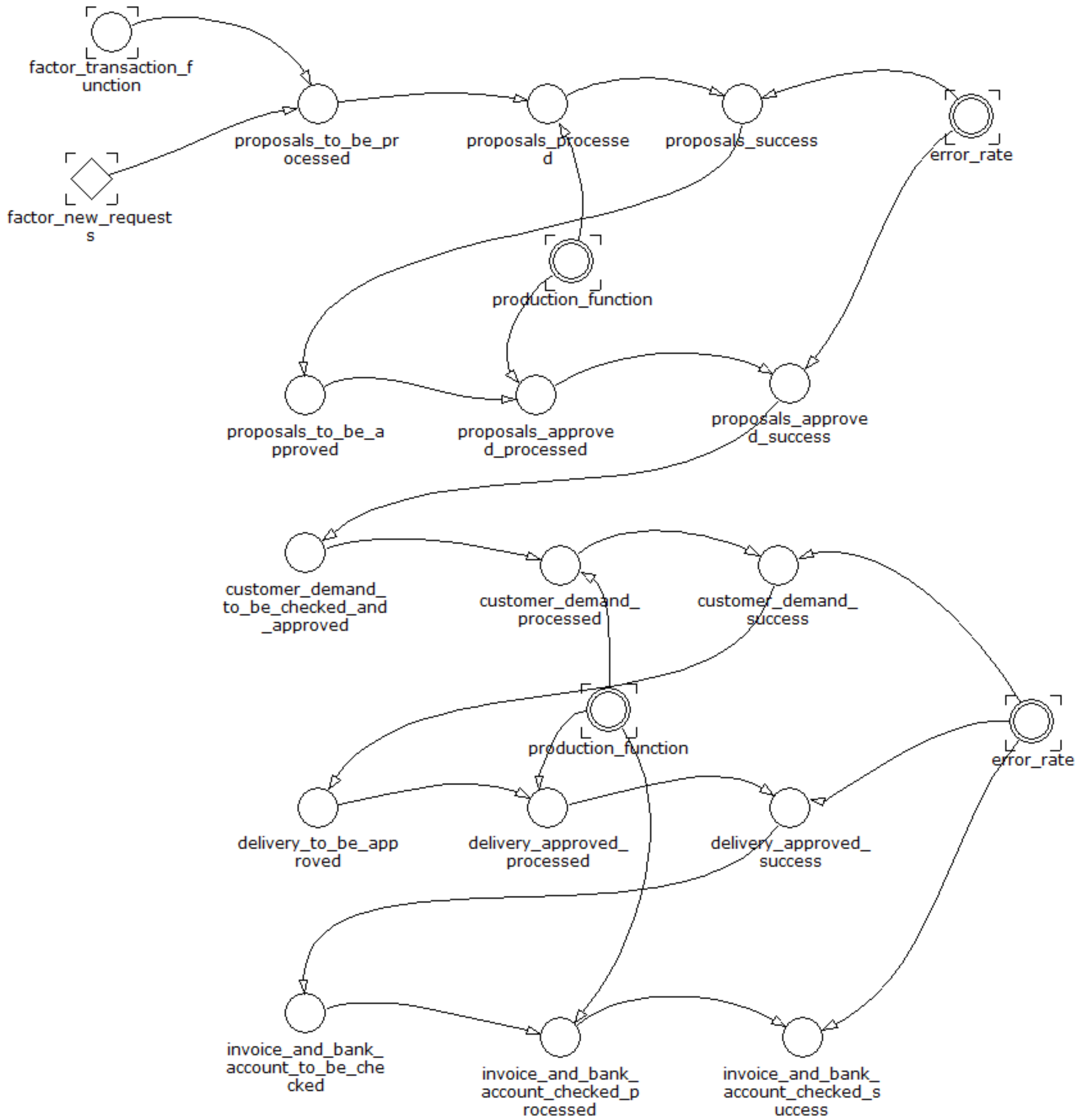


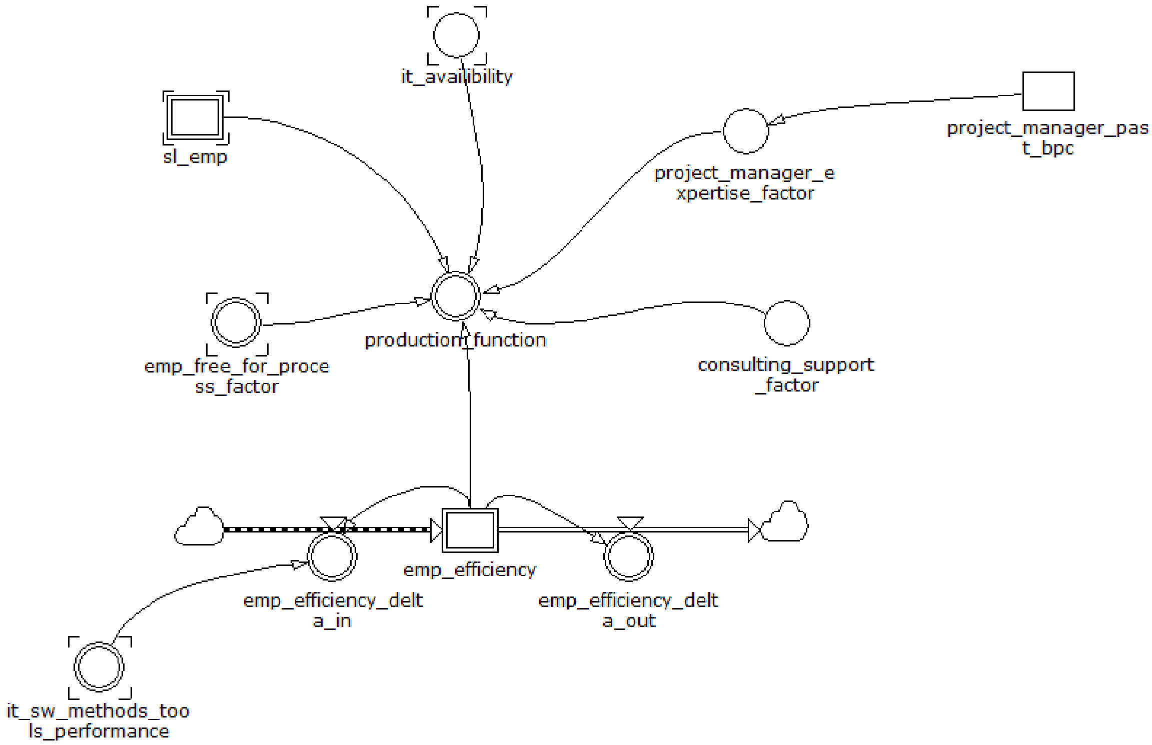

time_spent_in_training_factor
emp_hired
emp_for_training
avg_performance_emp_hired
emp_for_training
emp_con_sup_hired
1
emp_free_for_process_factor
emp
total_employee_available_for_proc
avg_performance_emp
total_employee_available_for_proc

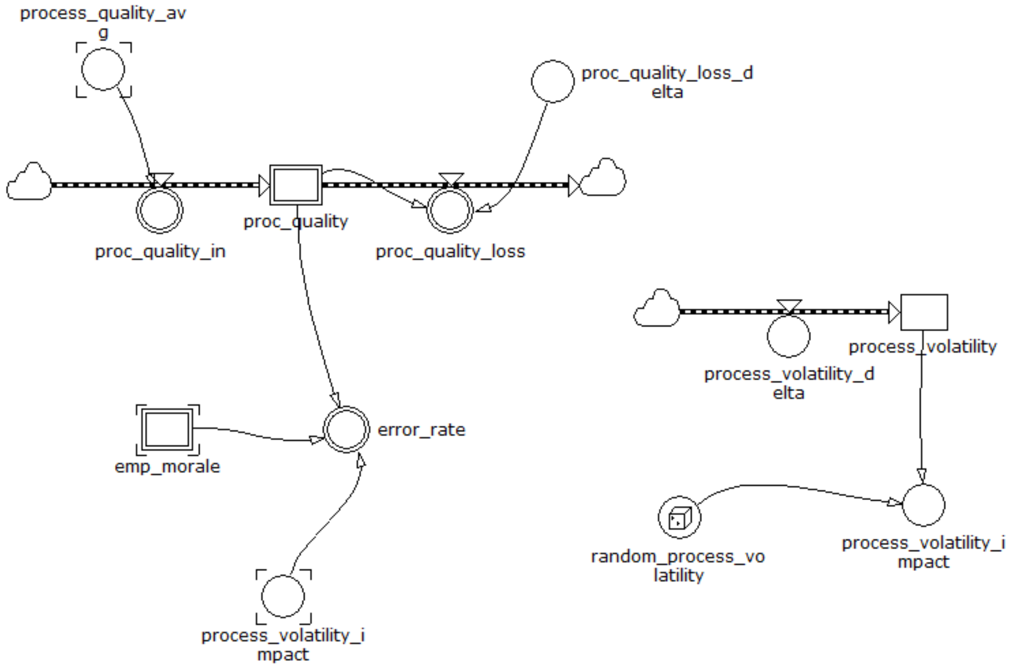

emp_training_forecast
emp_training_forecast_reset
time_spent_in_training_factor

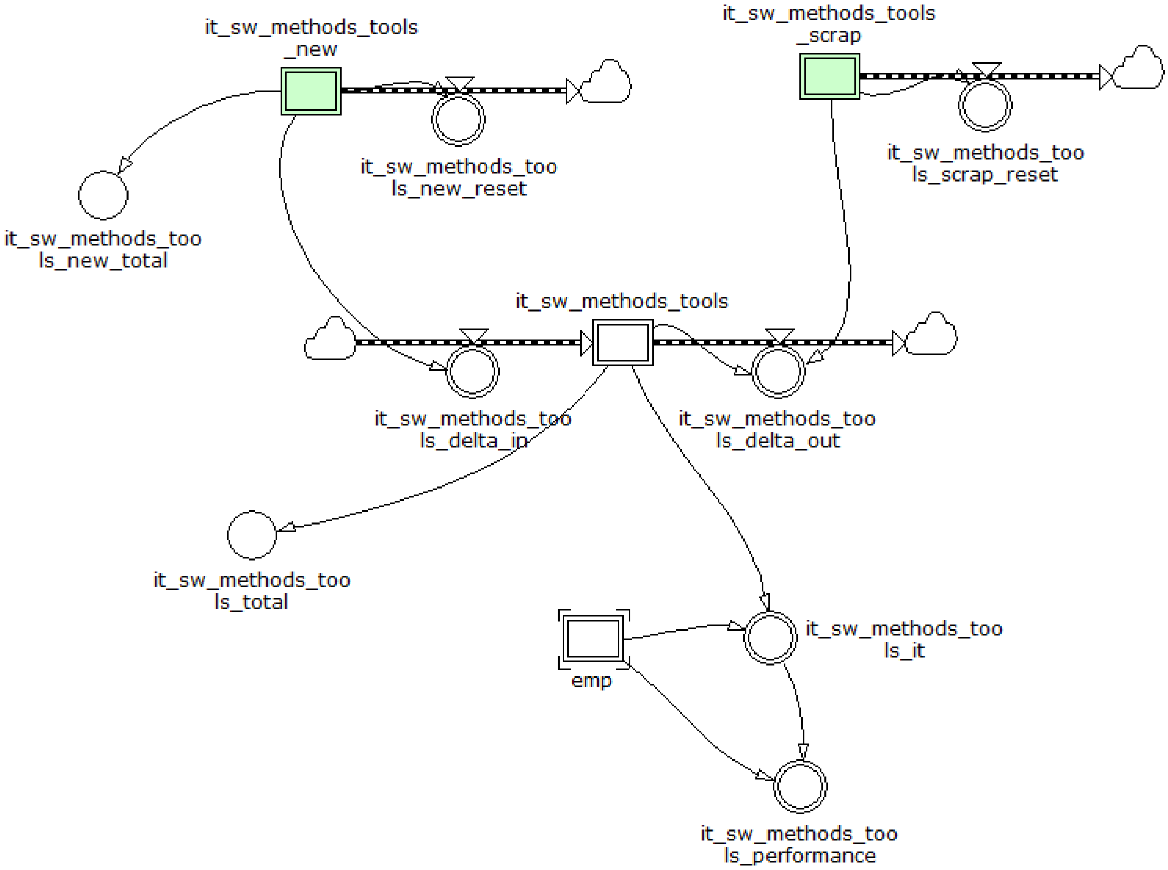

salary_emp_increase
reset_salary_emp_increase
salary_emp_decrease
reset_salary_emp_decrease
salary_emp
salary_emp_in
salary_emp_out
emp
emp_hired
emp_fired
costs_emp
costs_emp_hired
costs_emp_fired
costs_emp_hired_per_fte_delta
costs_emp_hired_per_fte
costs_emp_fired_per_fte_delta
costs_emp_fired_per_fte
costs_emp_hired_per_fte_increase
costs_emp_hired_per_fte_reset
costs_fired_per_fte_increase
costs_emp_fired_per_fte_reset

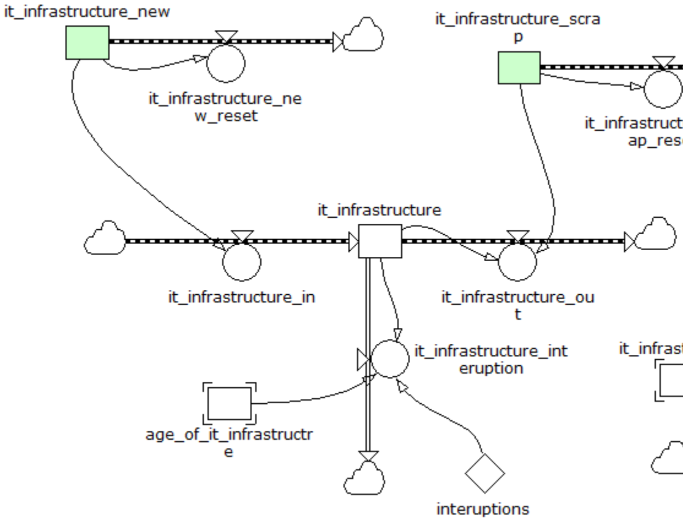

costs_emp_con_support_in
costs_emp_con_suppurt_in_reset
costs_emp_consulting_support
costs_emp_consulting_support_delta_in
emp_con_sup_hired
costs_consulting_support
consulting_support

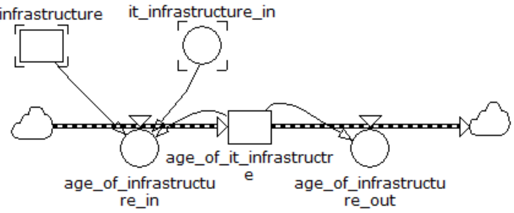

factor_transaction_f unction
factor_new_request s
proposals_to_be_pr ocessed
proposals_processe d
proposals_success
error_rate
production_function
proposals_to_be_a pproved
proposals_approve d_processed
proposals_approve d_success
customer_demand_ to_be_checked_and _approved
customer_demand_ processed
customer_demand_ success
production_function
error_rate
delivery_to_be_app roved
delivery_approved_ processed
delivery_approved_ success
invoice_and_bank_ account_to_be_che cked
invoice_and_bank_ account_checked_p rocessed
invoice_and_bank_ account_checked_s uccess

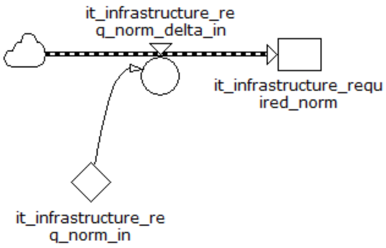

it_availibility
sl_emp
project_manager_pas
t_bpc
project_manager_e
xpertise_factor
emp_free_for_proce
ss_factor
production_function
consulting_support
_factor
emp_efficiency
emp_efficiency_delt
a_in
emp_efficiency_delt
a_out
it_sw_methods_too
ls_performance

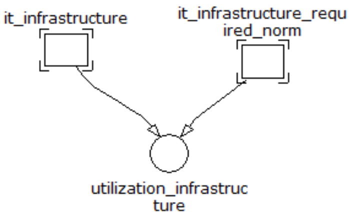

process_quality_av
g
proc_quality_loss_d
elta
proc_quality
proc_quality_in
proc_quality_loss
process_volatility
process_volatility_d
elta
error_rate
emp_morale
random_process_vo
latility
process_volatility_i
mpact
process_volatility_i
mpact

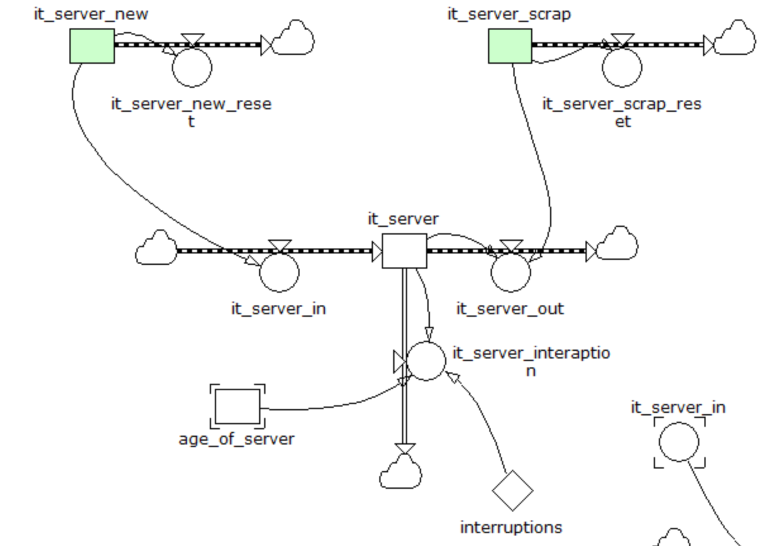

it_sw_methods_tools
_new
it_sw_methods_tools
_scrap
it_sw_methods_too
ls_new_reset
it_sw_methods_too
ls_scrap_reset
it_sw_methods_too
ls_new_total
it_sw_methods_tools
it_sw_methods_too
ls_delta_in
it_sw_methods_too
ls_delta_out
it_sw_methods_too
ls_total
emp
it_sw_methods_too
ls_it
it_sw_methods_too
ls_performance

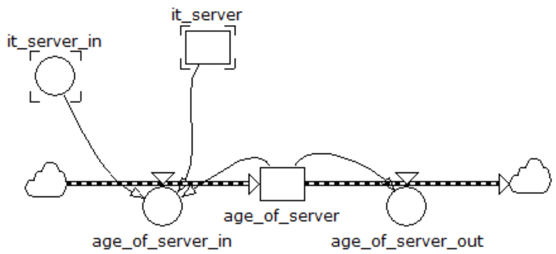

it_infrastructure_new
it_infrastructure_ne
w_reset
it_infrastructure_scra
p
it_infrastructure_scr
ap_reset
it_infrastructure
it_infrastructure_in
it_infrastructure_ou
t
it_infrastructure_int
eruption
age_of_it_infrastructr
e
interuptions

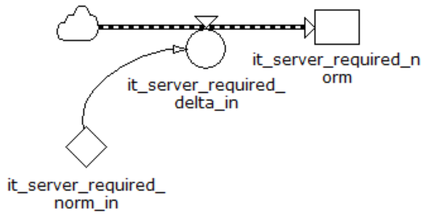

it_infrastructure
it_infrastructure_in
age_of_it_infrastructr
e
age_of_infrastructu
re_in
age_of_infrastructu
re_out

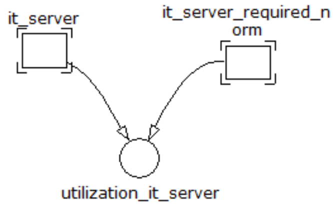

it_infrastructure_re
q_norm_delta_in
it_infrastructure_requ
ired_norm
it_infrastructure_re
q_norm_in

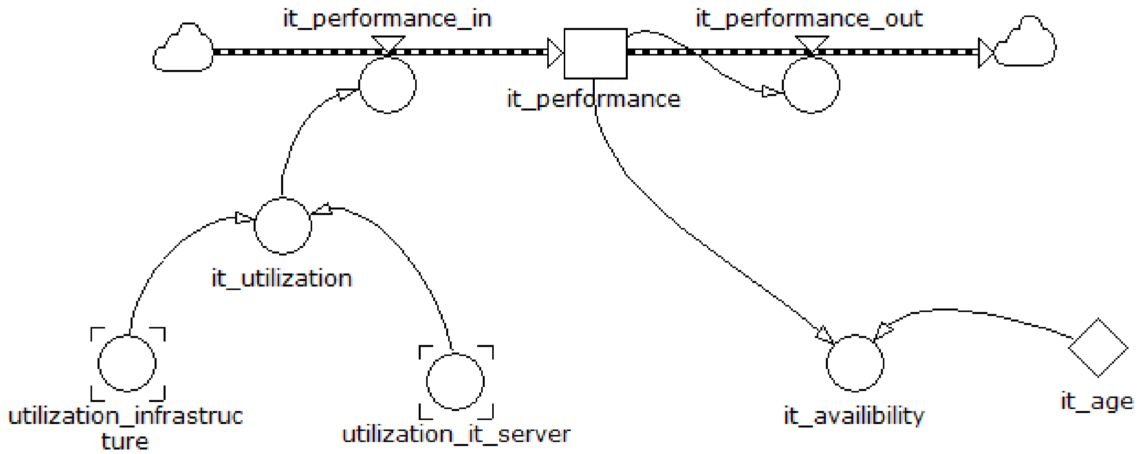

it_infrastructure
it_infrastructure_requ
ired_norm
utilization_infrastruc
ture

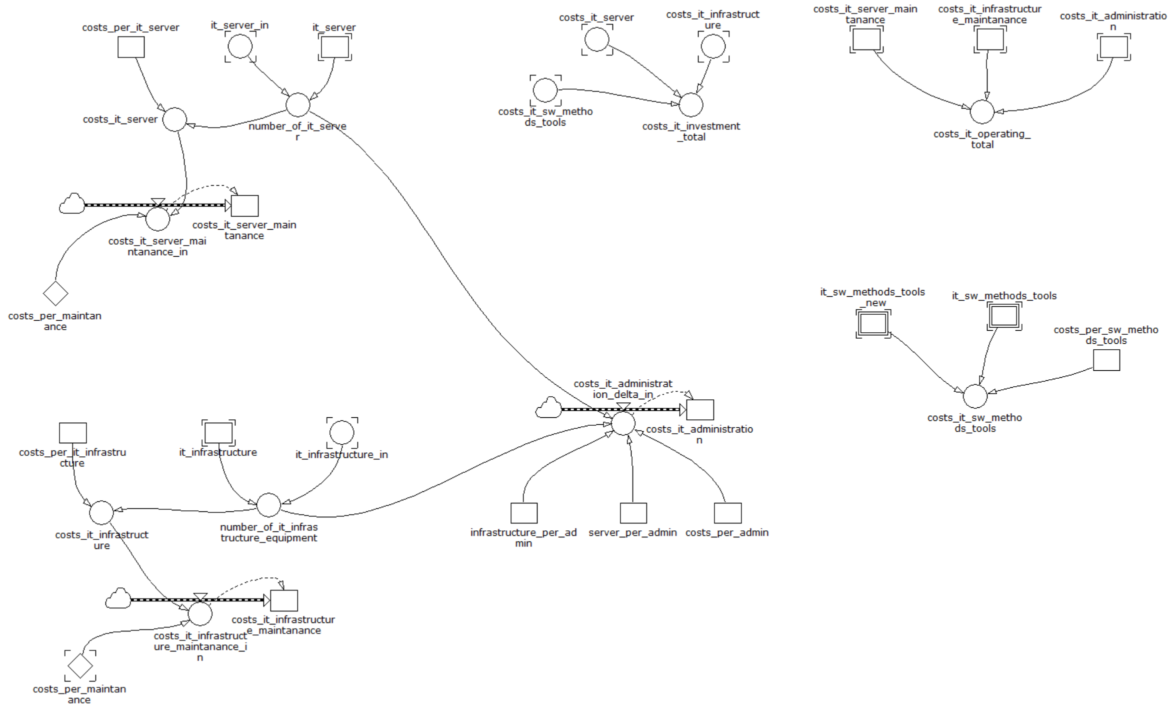

it_server_new
it_server_new_reset
it_server_scrap
it_server_scrap_reset
it_server
it_server_in
it_server_out
it_server_interaption
age_of_server
interruptions


it_server
it_server_in
age_of_server
age_of_server_in
age_of_server_out


it_server_required_norm
it_server_required_delta_in
it_server_required_norm_in


it_server
it_server_required_norm
utilization_it_server


it_performance_in
it_performance_out
it_performance
it_utilization
utilization_infrastructure
utilization_it_server
it_availibility
it_age



costs_per_it_server
it_server_in
it_server
costs_it_server
number_of_it_server
costs_it_server_maintanance_in
costs_it_server_maintanance
costs_per_maintanance
costs_it_server
costs_it_infrastructure
costs_it_sw_methods_tools
costs_it_investment_total
costs_it_server_maintanance
costs_it_infrastructure_maintanance
costs_it_administration
costs_it_operating_total
it_sw_methods_tools_new
it_sw_methods_tools
costs_per_sw_methods_tools
costs_it_sw_methods_tools
costs_it_administration_delta_in
costs_it_administration
costs_per_it_infrastructure
it_infrastructure
it_infrastructure_in
costs_it_infrastructure
number_of_it_infrastructure_equipment
infrastructure_per_admin
server_per_admin
costs_per_admin
costs_it_infrastructure_maintanance_in
costs_it_infrastructure_maintanance
costs_per_maintanance