TECHNISCHE UNIVERSITÄT MÜNCHEN

TUM School of Management

Lehrstuhl für Unternehmensführung

Continuous Improvement Management of Indirect Processes

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Vollständiger Abdruck der von der Fakultät für Wirtschaftswissenschaften der
Technischen Universität München zur Erlangung des akademischen Grades eines

Doktors der Wirtschaftswissenschaften (Dr. rer. pol.)

genehmigten Dissertation.

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Die Dissertation wurde am 07.04.2015 bei der Technischen Universität München eingereicht und durch die Fakultät für Wirtschaftswissenschaften am 15.06.2015 angenommen.

Acknowledgments

I wish to express my gratitude to my advisor, Professor Alwine Mohnen, who encouraged me to conduct research in my field of interest and guided me throughout the process of writing my dissertation. Furthermore, I would like to thank Professor Rainer Kolisch for examining my dissertation, and Professor Gunther Friedl for chairing the examination board. My thanks also go to all my colleagues at the Chair of Corporate Management for inspiring discussions, as well as their useful comments and suggestions during the process of writing this thesis. I am also grateful to Sibel Feix, Gabriele Jenke, Holger Kurth, Peter Schillo and Alexander Weichsel, who made it possible for me to conduct my research over the last few years, giving me the required freedom and always being available for in-depth discussions. Furthermore I would like to express my thanks to my colleagues and friends Thomas Fliedner and Kilian Moser for their support and, in particular, to Dr. Alessio Ishizaka and Dr. Jürgen Wagner for regularly pushing my research. Finally, I would like to extend a very special thank you to Claus Brech and Ann-Kathrin Mees, as well as to my parents for their indispensable support.

Table of Contents

Acknowledgments I

Table of Contents II

List of Figures IV

List of Tables VI

Abbreviations VII

1 Introduction 1

1.1 Continuous Improvement Management of Indirect Processes 3

1.2 Challenges and Research Objectives 5

1.3 Research Questions and Methodology 6

1.4 Structure and Summary of the Research 7

1.5 Research Ethics 10

2 Target Setting for Indirect Processes: A New Hybrid Method for the Continuous Improvement Management of Indirect Processes 11

2.1 Introduction 12

2.2 Literature Review 13

2.3 Methodology 14

2.4 Case Study 21

2.5 Discussion 28

2.6 Conclusion 30

2.7 Appendix 32

2.7.1 Steps of the Constructive Research Approach 32

2.7.2 General Remarks on the Analytic Network Process 32

2.7.3 Examination of an Analytic Network Process 33

3 Fair Centralized Allocation of a Resource Reduction Level among Processes 38

3.1 Introduction 39

3.2 Literature Review 40

3.3 Methodology 43

3.4 Case Study 50

3.5 Discussion 56

3.6 Conclusion 57

3.7 Appendix 59

3.7.1 Strain Function Extraction 59

3.7.2 Case Study Data Analysis 60

4 Where is the Success? Why the Success of Improvement Activities in Indirect Areas might not always be Identifiable – a Multiple Case Study Investigation ... 63

4.1 Introduction ... 64

4.2 Literature Review ... 65

4.3 Methodology ... 65

4.4 Results ... 70

4.5 Discussion ... 76

4.6 Conclusion ... 77

4.7 Appendix ... 79

4.7.1 Dimensional Analysis of Motivation ... 79

4.7.2 Interview Guideline ... 80

4.7.3 Likert Scale Criteria ‘Quality’, ‘Costs’ and ‘Delivery’ ... 81

4.7.4 Category System ... 81

4.7.5 Hypotheses Development ... 91

4.7.6 Expert Overview ... 102

4.7.7 Evaluation Scale of Tightened Hypotheses ... 103

4.7.8 Hypotheses Discussion ... 104

4.7.9 Recommendations Development ... 105

4.7.10 Efficiency and Realization Effort ... 106

5 Summary of the Results and Implications for Practice ... 107

6 Discussion and Future Research ... 108

7 Conclusion ... 109

Notations and Symbols ... 110

References ... 112

List of Figures

Figure 1.1: Structure of the thesis ... 8
Figure 2.1: Schematic method development ... 15
Figure 2.2: Adapted SC-VCC with data from Table 2.2 ... 21
Figure 2.3: Implementation stages of TSIP ... 22
Figure 2.4: Scheme of the process and activity model ... 23
Figure 2.5: Network design ... 25
Figure 2.6: VCC of implementation stage 3.a (left side) in comparison to SC-VCC with cost measures on both axes (right side) ... 27
Figure 2.7: Dimensions of weak market test ... 28
Figure 2.8: Phases and steps of CRA ... 32
Figure 2.9: Conceptual design of a hierarchy and a network ... 34
Figure 3.1: Method development ... 43
Figure 3.2: Exemplary illustration of a linearized utility and a strain function ... 49
Figure 3.3: Shapes of the strain curves and explanations ... 52
Figure 3.4: Turning point reduction level 10 million EUR ... 54
Figure 3.5: Turning point reduction level 10 million EUR in comparison to a reduction level of 11 million EUR ... 54
Figure 3.6: Exemplary certainty equivalence approach ... 59
Figure 3.7: Distribution of s_a at 10 million EUR cost reduction ... 62
Figure 3.8: Distribution of s_a at 11 million EUR cost reduction ... 62
Figure 4.1: Method steps ... 66
Figure 4.2: Interview sample ... 67
Figure 4.3: Shortened interview guideline ... 67
Figure 4.4: Causal chain ... 69
Figure 4.5: Case analysis ... 71
Figure 4.6: Cross case analysis hypothesis 3 ... 72
Figure 4.7: Causal chain hypothesis 3 ... 72
Figure 4.8: Hypotheses evaluation ... 74
Figure 4.9: Dimensional analysis of motivation ... 79
Figure 4.10: Likert scale ... 81
Figure 4.11: Cross case analysis hypothesis 1 ... 91
Figure 4.12: Causal chain hypothesis 1 ... 92
Figure 4.13: First cross case analysis hypothesis 2 ... 93
Figure 4.14: Causal chain hypothesis 2 ... 93
Figure 4.15: Second cross case analysis hypothesis 2 ... 94
Figure 4.16: Cross case analysis hypothesis 4 ... 94

Figure 4.17: Causal chain hypothesis 4 95
Figure 4.18: Cross case analysis hypothesis 5 96
Figure 4.19: Causal chain hypothesis 5 97
Figure 4.20: Cross case analysis hypothesis 6 98
Figure 4.21: Causal chain hypothesis 6 98
Figure 4.22: Cross case analysis hypothesis 7 99
Figure 4.23: Causal chain hypothesis 7 100
Figure 4.24: Cross case analysis hypothesis 8 100
Figure 4.25: Causal chain hypothesis 8 101
Figure 4.26: Evaluation scale 103
Figure 4.27: Ratio of efficiency and realization effort 106

List of Tables

Table 2.1: Core strengths and limitations of the methods used 15
Table 2.2: Example of calculations for the SC-VCC 21
Table 2.3: Importance criteria from the literature 23
Table 2.4: Extract of calculations for the SC-VCC of stage 3.a 26
Table 2.5: Fundamental evaluation scale 35
Table 3.1: Forward citation review of centralized resource allocation 41
Table 3.2: Linearized concave utility function of type 2 53
Table 3.3: Δ_{rawl} for various reduction goals G 53
Table 3.4: Comparison of w at turning point 55
Table 3.5: Comparison of the results of different allocation proceedings 56
Table 3.6: Case study raw data 60
Table 3.7: Analysis for Δ=0.23 and G=10 million EUR 61
Table 4.1: Interview guideline 80
Table 4.2: Category system 82-90
Table 4.3: Expert overview 102
Table 4.4: Summarized results of expert discussion 104
Table 4.5: Developed recommendations by experts 105

Abbreviations

ABC	Activity-Based Costing
ABM	Activity-Based Management
AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
C	Cost
CR	Consistency Ratio
CRA	Constructive Research Approach
D	Delivery
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EE	Representative Employee
EFQM	European Foundation for Quality Management
LM	Lower Manager
LO	Logistic
MILP	Mixed-Integer/Linear Programming
MM	Middle Manager
P	Project
PDCA	Plan-Do-Check-Act
Q	Quality
QM	Quality Management
SC-VCC	Subsidization and Capacity Considering Value Control Chart
TE	Technical Engineering
TSIP	Target Setting for Indirect Processes
VCC	Value Control Chart

1 Introduction

Driven by globalization, resource shortages, and reduced innovation cycle times, industrial organizations aim for improvements of their processes to keep pace with competitors (Abele & Reinhart, 2011; Fehr et al., 2011). In this context, the concept of continuous improvement has attracted particular attention (Singh, J. & Singh, H., 2015). After years of focusing primarily on the optimization of direct processes, less potential for improvement can be found among them (Becker et al., 2007). As a result, indirect processes – those processes that support the directly value generating processes of an organization, such as maintenance or intra-logistics – are gaining strategic importance: They are evaluated as still having major potential for improvement (Horváth & Partners, 2009; Schneider et al., 2011; Reinhart & Magenheimer, 2011), while their total share of all business processes is also increasing (Renner, 2005; Moritz & Heiss, 2012). Consequently, improvement programs aiming at business excellence in indirect processes have recently attracted significant attention (e.g., Deiwiks et al., 2008; Fehr et al., 2011; Wald et al., 2013). The need for such initiatives, particularly in large industrial organizations that utilize a high degree of technology and in which labor costs are intensive should be highlighted (e.g., Middel et al., 2007; Seidenschwarz et al., 2009; Schuh et al., 2010); for example:

> *We cannot lose any time. In light of the industry crisis we are facing great challenges. […] We can get more flexible, faster and more economical. There lays great potential in development, sales and all other indirect areas as they make up to half of our workforce. We want to increase productivity in the next years by 10 percent.*

(Horst Neumann - Board Member of Volkswagen AG; translation by the author)[1]

Advanced management methods are essential to achieve such improvement goals. The requirements for such methods are similar to those of value-oriented process management approaches (e.g., Buhl et al., 2011). They should enable decision makers to decide where and to what extent improvements can be achieved (1), as well as to ensure the sustainability of executed improvement measures (2) while still being economically manageable (3). However, these requirements are not satisfactorily fulfilled by existing approaches.

A prerequisite to fulfilling the first requirement is to enable the identification and quantification of improvement potential among the indirect processes of an organization. The academic literature discusses several methods of achieving this. These methods aim to reveal potential by, among others, mapping the indirect processes performed (e.g., Value Stream Mapping –

[1] Original statement (Manager Magazin, 2009): “Wir haben keine Zeit zu verlieren. Angesichts der Branchenkrise stehen wir vor großen Herausforderungen. […] Da können wir noch flexibler, schneller und wirtschaftlicher werden. Hier ist ein großes Potenzial, denn Entwicklung, Vertrieb und die anderen indirekten Bereiche machen die Hälfte der Belegschaft aus. Wir wollen die Produktivität in den nächsten Jahren jährlich um 10 Prozent steigern.“.

Keyte & Locher, 2004), analyzing reference processes (e.g., benchmarking – Gleich et al., 2008), evaluating accounting figures (e.g., Activity-based Costing [ABC] – Cagwin & Bouwman, 2002) or examining ratio analysis (e.g., overhead and activity value analyses – Neumann, 1987)[2]. The approaches offer promising aspects; however, they are limited in their scope of application in terms of the demand for a comprehensive and simultaneously precise planning methodology in indirect processes. In particular, the specifics of indirect processes in business practice are difficult to address fully via these approaches. Indirect processes are often characterized by high levels of complexity and interdependence, as well as by uniqueness, making it problematic to compare them among organizations, and especially difficult to analyze with regard to improvement potential (Becker et al., 2007; Schuh et al., 2012). As a result, managerial decisions concerning the allocation of improvement targets among the indirect processes of an organization often face uncertainty. In addition, no single approach to date incorporates mechanisms to ensure that the same target setting policy, for example with regard to fairness, is ensured across all the indirect processes of an organization.

The characteristics of indirect processes described, namely complexity, interdependence, and uniqueness, lead to a further challenge in respect of the second requirement regarding the sustainability of improvement programs. Organizations that have already rolled out improvement programs in indirect processes report that, despite being a difficult task in general (Schroeder & Robinson, 1991; Davenport, 1993; Ozawa, 2007; Bernett & Nentel, 2010; Kamprath & Röglinger, 2011), appropriate pinpointing of the success of the improvement activities often fails. If a manifestation of the achieved improvements is not possible, the same negative consequences as not being successful at all could result. Why organizations sometimes fail to point out the success of improvement initiatives in indirect processes has not been addressed in any scientific research thus far.

Following a problem-induced research approach (Ulrich, 1984), the challenges derived from the first two requirements were formulated as the research objectives of this thesis. While addressing these research objectives, the third requirement concerning the economic implementation and realization of new methods has also been considered. The methods developed and the insights generated by this dissertation will contribute to the research fields of decision-making in general and to the context of continuous improvement management in indirect processes in particular. In addition, the results can assist decision makers to sustain the competitiveness of their organizations in business practice, as demonstrated in the case studies that were examined.

After a short introduction defining continuous improvement management in indirect processes, the research questions addressing the objectives will be derived. The introduction concludes by outlining the structure of the thesis and how it will address the research questions.

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[2] Both approaches have to be positioned in the context of business process reengineering (Rigby, 1993).

1.1 Continuous Improvement Management of Indirect Processes

Business practice relies heavily on continuous improvement programs (Kirner et al., 2006; PricewaterhouseCoopers, 2011), making such programs the preferred concept to secure business excellence (Hess & Schuller, 2005). A variety of concepts have emerged under the principle of continuous improvement[3]. Prominent examples include lean management, total quality management, and Six Sigma (Berger, 1997; Caffyn, 1999; Bhuiyan & Baghel, 2005; Albright & Lam, 2006). All these approaches share the common goal of waste reduction (Johnson, 1988), described by the Japanese word *muda* (Womack & Jones, 2003), and the assumption that larger improvements can be achieved by the sum of several small improvements (Bhuiyan & Baghel, 2005) in the sense of *kaizen* (Imai, 1986). In general, continuous improvement has to be distinguished from other improvement concepts, such as business process reengineering, which aims at a total redesign of the existing process structure (Gaitanides et al., 1994; Hess & Schuller, 2005). For the purpose of this research, continuous improvement will be defined as a concept that aims to make a "job […] easier, quicker, safer, cheaper, and more accurate. In other words, the efficiency is improved" (Robinson, 1991, p. 226). In this regard, efficiency is measured by a comparison of the efforts required to reach a pre-defined, specific value contribution (Cantner et al., 2007). Despite the assumption that continuous improvements are ideally supposed to emerge from the organization itself (Rother, 2013), purposeful management of improvement activities is required to achieve overall organizational targets in business practice (e.g., Fehr et al., 2011). Therefore, controlling circuits are crucial, incorporating (among others) planning and control steps. In this context, the continuous improvement concept of plan-do-check-act (PDCA)[4] should be mentioned. Being primarily a methodological approach to addressing (quality) issues related to product development (Imai, 1986), the iterative circle characteristic of PDCA (see Figure 1.1), making it a more general management instrument to attain improvements (Syska, 2006), should act as guidance for putting the research challenges and objectives of this dissertation in context. The problems in the field of potential improvements are first identified, and measures to realize them are then planned (P). After the improvement measures are realized (do - D), the results are checked (C) with regard to their degree of fulfillment. Whether the results are satisfactory or not, it is returned to the planning step to determine whether to take further action (A) or to implement the solution standards.

While primarily targeting the improvement of direct processes, continuous improvement programs have recently also included indirect processes to achieve overall business excellence (Faust, 2009; Schuh et al., 2010; Fehr et al., 2011). Indirect processes do not generate value in the original sense, but do serve internal customers, thus enabling them to generate value when serving

[3] An overview of the historical development of the philosophy of continuous improvement can be found in Schroeder and Robinson (1991).

[4] PDCA is often associated with the Deming wheel, although the root of the idea dates back to Shewhart in the 1930s (Moen & Norman, 2010).

external customers (Thomas & Hemmers, 1981; Dellmann et al., 1994; Fehr et al., 2012). A process in this context represents the summary of structured and measurable activities aiming for the generation of a specific output (Davenport, 1993). An activity only belongs to one process. Indirect processes range from superior (such as marketing and human resources), upstream (such as purchasing and preparation) and accompanying processes (such as maintenance and setting) to downstream functions (such as outbound logistics and customer service (Thomas & Hemmers, 1981; Wildemann, 2009)[5]. An inherit assumption is that their efficiency is increased when they either deliver the same level of support with fewer resources, or a higher level of support using the same resources. In a study by Horváth & Partners (2009), 85% of the participating organizations believed that indirect areas have major potential for improvement (compared to 61% in direct areas). This is in line with the findings of a study by the Institute for Machine Tools and Industrial Management (iwb) at TU Munich (2011), which revealed that approximately 33% of the processes that were examined in indirect areas do not add any (internal) value, implying a large improvement potential (Reinhart & Magenheimer, 2011). In addition, a study of Fraunhofer IPA (Schneider et al., 2011) revealed that indirect areas are evaluated as being the main focus area for improvements in the future (evaluated at 38%, compared to 21% for direct areas).[6] This is further emphasized by the findings of a study by Seidenschwarz et al. (2009), in which 67% of the participating organizations believed that the efficiency of indirect areas would gain increasing strategic importance. This is particularly the case for industries that are characterized by a large proportion of indirect processes, as is often found in high technology and labor-intensive fields,[7] in which competition is fierce (Middel et al., 2007), and the topic of improvement management in indirect processes is already of specific interest (Schuh et al., 2010). If improvement initiatives in indirect areas are intended, they are often rolled out in ways similar to initiatives in direct areas (Faust, 2009; Specht et al., 2011; Fehr et al., 2012). This is because most companies rolling out programs in indirect processes have already gained experience with continuous improvements in direct processes, and assume that indirect processes can be managed in a similar way. However, continuous improvement management in indirect areas poses specific challenges that have not been addressed appropriately thus far, limiting the chances of the success of these initiatives. Based on these challenges, the research objectives of this thesis are formulated in Chapter 1.2.

5 In English-speaking economies, superior functions are often referred to as overhead processes.

6 If the focus is specifically on superior functions, such as overhead processes as prominently discussed by Miller and Vollmann (1985), some might summarize continuous improvement activities in these areas under the terms ‘lean administration’ or ‘lean office’ while, for the purpose of this thesis, these should be considered as only one element of continuous improvement management in indirect areas.

7 For example, the total share of indirect processes of the total hours per vehicle (HPV) increased to nearly 30% in 2011, compared to 22% in 2007 (Moritz & Heiss, 2012).

1.2 Challenges and Research Objectives

Challenge of identifying improvement potential

Compared to direct processes, indirect processes share several characteristics that complicate the identification of improvement potential among them during the business planning and budgeting stages (Becker et al., 2007; Schuh et al., 2013; Magenheimer et al., 2014): Indirect processes are less likely to be driven by clearly separable and iterative tasks, but rather by, as said before, complexity and high levels of interdependence among them and their subordinated activities. Furthermore, the means of exchange between indirect processes is often loosely structured intangible information (Keyte & Locher, 2004). In addition, mapping of the process and the measurement of basic performance indicators often does not exist (Picot & Liebert, 2011), making it very difficult to draw on dependable benchmarking figures (Deiwiks et al., 2008).

As a result, improvement initiatives in indirect areas have been normally limited to primary operational approaches (Magenheimer et al., 2014), such as value-stream mapping, analysis and the design of single processes (e.g., Keyte & Locher, 2004), or 5/6S (e.g., Schuh et al., 2013)[8]. On the other hand, if the strategic planning of improvements is intended, the result is often unstructured, intuitive, and unmonitored decisions, or even blanket cost-cutting strategies (Lee & Covell, 2008; Schuh et al., 2010; Schuh et al., 2012). This could lead to the situation that resource level reductions are allocated to processes that are of strategic importance (Deiwiks et al., 2008). Approaches that could potentially facilitate advanced strategic decision-making in this context, such as ABC (Cagwin & Bouwman, 2002) or benchmarking (Gleich et al., 2008), often struggle to address the characteristics of indirect processes in business practice appropriately[9]. In summary, there exists no established ‘gold standard’ concerning how to plan for improvements at present with regard to financial matters derived from the strategic goals of an organization in general (Kamprath & Röglinger 2011), and in indirect processes in particular. Consequently, a proper starting point for an iterative improvement process in the PDCA sense is largely missing. This limits the potential of improvement initiatives to contribute to the overall strategic goal of increasing the competitiveness of the organization. This challenge was formulated as the first research objective:

Objective 1: Enhancement of the planning of improvement activities in indirect processes.

[8] 5S and 6S are methodologies that aim to increase the efficiency and effectiveness of workplaces. The name is a composition of the first letters of the Japanese words *seiri*, *seiton*, *seiso*, *seiketsu* and *shitsuke* for 5S, with the addition of *shukan* for 6S (Takeda, 2006). In the English-speaking context, the terms sort, straighten, sweep, standardize, self-discipline (5S) and safety (6S) are often used (e.g., Browning & Heath, 2009).

[9] ABC and benchmarking will be reflected in the papers of this thesis in detail with regard to their abilities and limitations to support the planning of continuous improvement activities in indirect areas.

Challenge of recognizing improvements

Driven by the characteristics of indirect processes described previously, pointing out the success of continuous improvement activities in these areas, such as the reduction of waste, is a further major challenge (Fehr et al., 2011). In the worst-case scenario, the inability to pinpoint achievements appropriately can mislead top-management and cause them to abandon plans for further improvements. This could lead to the same negative consequences as not being successful at all in improving any indirect processes, thus risking the competitiveness of the organization in the long run. The observed inability to pinpoint success is especially worth examining in situations in which the managers involved in improvement projects are convinced of the success of the activities – which is often the case (Bernett & Nentel, 2010). To date, mechanisms for the identification of the success of improvement activities in indirect areas have not been examined in the research. So far, research has focused on factors enhancing the achievement of improvements in indirect areas (e.g., Schuh et al., 2012; Wald et al., 2013). To facilitate the recognition of the success of improvement activities in indirect areas in the PDCA sense a further objective was therefore formulated:

Objective 2: *Facilitation of the identification of successful improvement activities in indirect processes.*

1.3 Research Questions and Methodology

To address the above-formulated research objectives, three research questions were derived, and are investigated in the three papers presented in this thesis. In each of the first two papers, a new method was developed and empirically examined in real case settings, while the third paper examined a multiple case study research, incorporating a qualitative empirical data analysis.

With regard to the complexity of the first research objective of planning improvement activities in indirect areas, two specific research questions were derived. These were addressed in the first two papers presented in this thesis. To facilitate comprehensive problem structuring and the development of a new approach, as well as to test it in business practice, the constructive research approach (CRA) was applied in the first paper (Kasanen et al., 1993). The first paper addressed the following research question:

Research question 1: How to identify indirect processes featuring improvement potential?

Based on the findings of the first paper, the aim of the second paper was to facilitate the rational and fair allocation of resource level reductions within an organization by top decision makers. To do so, a methodological framework was developed and tested in a case study approach. Therefore, paper 2 addressed the following research question:

Research question 2: How to allocate a pre-defined resource reduction level among processes of a single organization considering their resource efficiency and overall allocation fairness?

Research on identifying the success of improvement activities in indirect areas is still negligible. Therefore, an inductive process was conducted to address the second research objective. Driven by the idea that failed projects can yield interesting insights (de Wit, 1988; Edmondson, 2011), projects struggling to point out improvement success were examined. This was done via a multi-step analysis based on a holistic multiple-case design (Yin, 2009). Considering that the success of improvement activities depends to a large extent on human factors (Imai, 1986; Robinson, 1990), expert interviews were conducted to gain access to relevant information. The corresponding question in paper 3 is:

Research question 3: Which circumstances are complicating the identification of the success of improvement activities in indirect areas?

The investigated case industry in all three papers is the automotive industry. As the automotive industry is a technological pioneer in many fields, while also being driven by a large share of indirect processes and significant cost pressure (Moritz & Heiss, 2012; Stolz & Berking, 2013; Roland Berger, 2014), it is an ideal object of investigation for the research purpose of this thesis.

1.4 Structure and Summary of the Research

The structure of the thesis is outlined in Figure 1.1. Papers 1 and 2 (Chapter 2 and 3) addressed the first research objective of aiming for the facilitation of the planning of improvement activities in indirect areas (while also dealing with aspects of doing and checking in the PDCA sense). Paper 3 (Chapter 4) addressed the second research objective, intending to enhance the identification of the success of improvement activities in indirect processes (while also enhancing the aspects of doing and acting in the PDCA sense). Each paper has an independent structure, including an introduction, a review of the relevant literature, and a conclusion. Further information, such as general method definitions and detailed data analysis, are included in the respective appendixes of the papers.

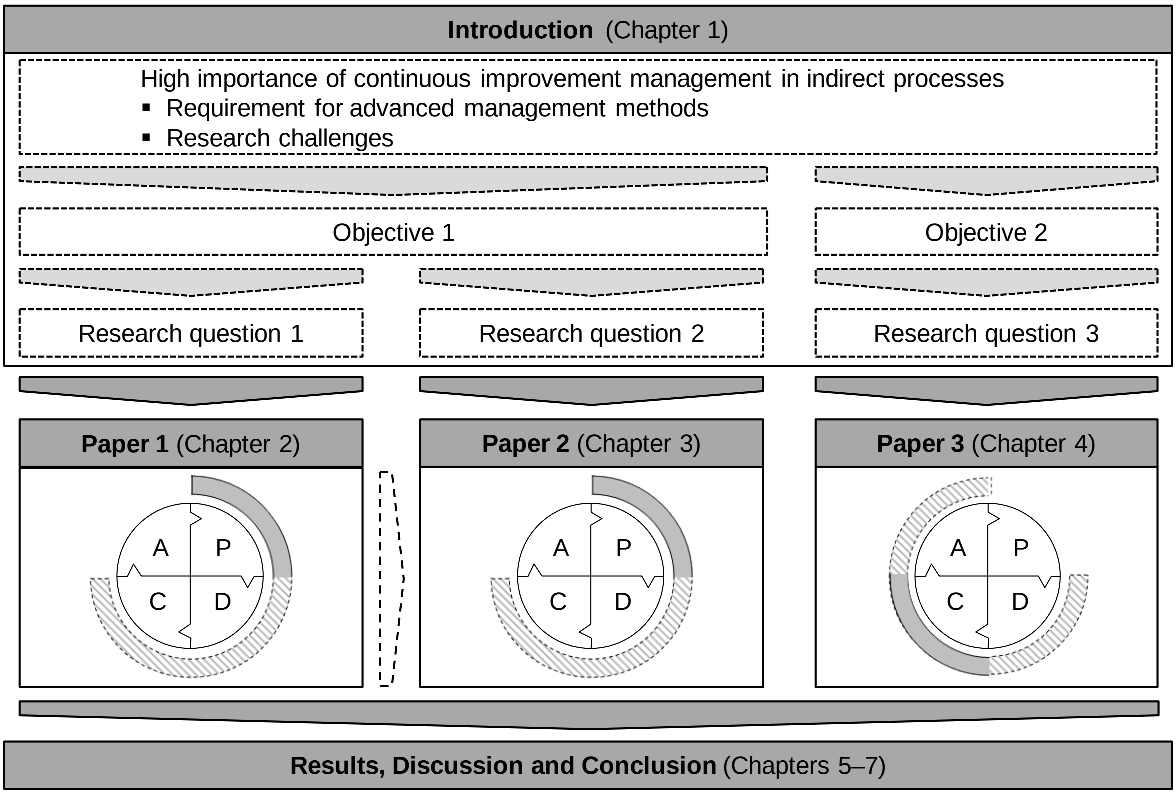

Figure 1.1: Structure of the thesis (own illustration)

Paper 1: Target Setting for Indirect Processes: A New Hybrid Method for the Continuous Improvement Management of Indirect Processes

The aim of the first paper was to develop an approach to identify the improvement potential of the indirect processes of a first-tier automotive supplier plant. As (external) benchmarking is mostly not feasible in the context of indirect processes, the first challenge was to create an alternative decision-making data basis. An Analytic Network Process (ANP) analysis was used to determine the contribution level of each indirect process and its corresponding activities to ensure the operability of the respective direct process. The network design underlying the ANP analysis enabled a group decision process involving experts from different departments of the organization. To allow for an efficiency analysis in a further step, the costs of the activities were determined with the assistance of activity-based management (ABM). All data were finally placed in relation in an adapted value control chart (VCC), allowing for the derivation of improvement targets. Within the case examination, following the CRA approach, the method demonstrated its usability. Applications of the developed Target Setting for Indirect Processes (TSIP) method in contexts other than that of financial improvement are deemed feasible. The ability to derive quantified improvement targets on an activity level based on an efficiency analysis gives the approach a distinctive character in research on decision-making.

Paper 2: Fair Centralized Allocation of a Resource Reduction Level among Processes

The continuous improvement of operating units in financial matters aims at the reduction of the resources consumed if the outputs of the units are to stay constant over time. As a basis for decisions to reduce resources, for example within budgeting processes in a performance analysis, the Data Envelopment Analysis (DEA) has received distinct attention in academic discussions. However, the existing approaches do not always allow for the meaningful allocation of resources. In addition to missing benchmarking figures, methodological problems emerge if the desired total reduction level is lower than the maximum total reduction level of all units determined by the DEA analysis. For these common decision-making scenarios in business practice, a two-step approach was developed, which incorporates DEA and a mixed-integer/linear programming (MILP) formulation of a social welfare function. In the first step of this method, the processes of an organization are conceived of as decision-making units (DMU), and their costs are used as input and their value as output in a DEA. In the second part, the aspect of fairness is addressed, based on the MILP formulation of a social welfare function: The decision maker can make a tradeoff regarding whether the limited resources should be allocated by means of utilitarianism or equity among the activities and processes. The method was applied in a real case setting of a first-tier automotive supplier plant, demonstrating its applicability to facilitate a comprehensive target-setting procedure in indirect areas.

Paper 3: Where is the Success? Why the Success of Improvement Activities in Indirect Areas might not always be Identifiable – a Multiple Case Study Investigation

Apart from the achievement of improvements in indirect areas, identifying these improvements is a challenge that has been neglected in scientific research thus far, although it is described as a major showstopper in business reality. To determine the factors that limit the potential clout of continuous improvement activities in indirect areas, an inductive multi-step case analysis was performed. The case organization is a first-tier automotive supplier. Six cases (projects struggling to point out the success of the activities) were examined, and 18 experts were interviewed. The results were analyzed using a qualitative content analysis. Based on these analyses, hypotheses were derived covering the potential circumstances that might explain why the success could not be identified. These hypotheses were evaluated and then scrutinized in expert group discussions. The aim of this approach was to ensure a high level of communicative and intra-organizational validity. If the occurrence of the identified circumstances can be prevented, the primary achievement of any success can also potentially be enhanced, whether in indirect areas or elsewhere. Such circumstances deal with aspects of transparency, diffusion, target tracking, information exchange, and individual freedom within improvement projects.

1.5 Research Ethics

In all three papers, the same first-tier national European Foundation for Quality Management (EFQM) award-winning automotive supplier was the subject of analysis. A comprehensive report concerning the organization's maturity level in respect to continuous improvement management in indirect areas can be found in Gackstatter et al. (2011) and Merkl (2012). Although the cooperating organization was involved in funding the doctoral studies, the organization did not impair the results of this study at any stage. The authorship of the three papers should be specified as follows:

Paper 1

Authors: Ihrig, Sebastian *(first author)*; Ishizaka, Alessio; Mohnen, Alwine

In this paper, I was in charge of the formulation of the research question, the structure of the research process, and major elements of the proposed method. Furthermore, I conducted all the data analyses. As the author, I wrote large parts of the paper while staying at Portsmouth University between February and March 2013.

Paper 2

Authors: Ihrig, Sebastian *(first author)*; Brech, Claus; Fliedner, Thomas; Ishizaka, Alessio

As the author of this paper, I formulated the research question and developed the research approach. I conducted the data analysis, as well as the method development together with the co-authors.

Paper 3

Authors: Ihrig, Sebastian *(first author)*; Mohnen, Alwine

In this paper, I was in charge of the derivation of the research question, conducted all data analyses, developed the structure of the research approach, and wrote the paper.

2 Target Setting for Indirect Processes: A New Hybrid Method for the Continuous Improvement Management of Indirect Processes

Indirect processes are increasingly contributing to the total cost of production in highly competitive and technology-intensive industries. Unfortunately, they are less assessable than direct processes due to the complex organizational management structure. Therefore, companies seeking to make improvements in indirect areas need decision support methods to indicate which indirect process needs to be improved and to what extent. To facilitate this task, the Target Setting for Indirect Processes (TSIP) method has been developed following the constructive research approach. TSIP is a combination of the Analytic Network Process with activity-based management from managerial accounting research, and the value control chart from target costing research in a kaizen budgeting framework. This new hybrid method was developed and validated in cooperation with a global first-tier automotive supplier.

Keywords: Analytic Network Process; Constructive Research Approach; Continuous Improvement; Indirect Processes; Activity-Based Management

Pre-release: A short paper of this research was presented at the 13th International Symposium on the Analytic Hierarchy Process 2014 (ISAHP2014) in Washington D.C., where it was awarded the Best Application Paper Award (third place).[10]

[10] The paper is available at http://www.isahp.org/uploads/p730332.pdf (last accessed 03.04.2015).

2.1 Introduction

The pressure of globalization, competition, reduced cycle times and increasing product complexity requires companies to improve their business processes and as a result, indirect processes have gained recent attention due to fewer improvement potentials being found in direct areas (Becker et al., 2007; Deiwiks et al., 2008; Fehr et al., 2011).

Internal indirect business processes are not directly generating value. Instead, they are required to keep the direct value-generating processes running. They are often less structured and sequential than direct processes, while driven by high levels of interdependencies, causing difficulty in identifying potential improvements (Schuh et al., 2013; Magenheimer et al., 2014). The selection of indirect processes that need improvement in that they become more cost-efficient, is often based on unstructured, intuitive and unmonitored decisions, or even on blanket cost-cutting strategies (Hambrick & Schecter, 1983; Lee & Covell, 2008; Schuh et al., 2010; Schuh et al., 2012). For example, a cost-reduction goal achieved by all departments and indirect processes contributing at the same level, risks the satisfaction of customer requirements, because essential processes may no longer work following reduction. Consequently cost-reduction exercises may even lead to the paradox of increasing costs in the future or in the need for other processes to compensate for this weakness (Roach, 1991; King, 1993). The continuous improvement planning in indirect processes, especially from a financial perspective, is therefore, a delicate issue, which despite its importance, has barely been examined in recent research (Wald et al., 2013). The ensuing question is: *How to identify indirect processes featuring improvement potential?*

To solve this problem, we developed a new decision-making method: Target Setting for Indirect Processes (TSIP). The method combines the Analytic Network Process (ANP) with methods from managerial accounting research, namely activity-based management (ABM), and from the target costing area, value control chart (VCC), which has been further developed for the purpose of this research. The TSIP method was developed by following the constructive research approach (CRA) (Kasanen et al., 1993), in cooperation with a first-tier automotive supplier. CRA facilitates the development of a new construct that enables scholars to solve practical problems while ensuring objectivity, criticalness and autonomy, as well as gaining insights not available using traditional research methods (Lukka, 2000; Lukka, 2002; Malmi, 2010). The CRA reduces the gap between research and practice (Lukka, 2000) and is generic enough to be applied to any area (Kasanen et al., 1993). The original six steps, introduced by Kasanen et al. (1993) to perform constructive research, have been extended to seven steps by Lukka (2000), which have been used in studies among others by Mendibil & MacBryde (2005) and Lindholm (2008). An overview of the steps can be found in Appendix 2.7.1. The seven steps are interwoven in the structure of this paper: Chapter 2.1 covers step 1 and 2, finding a practical relevant problem that has research implications, and examining the possibility for long-term research cooperation. Chapter 2.2 looks at step 3 by obtaining both a general and comprehensive understanding of the topic, while Chapter 2.3 describes the proposed approach and outlines step 4 by constructing a theoretically grounded solution. Chapter 2.4 presents the case examination ranging over a period of two years, as well as covering step 5 by implementing the solution and testing it in practice. Chapter 2.5 discusses the scope of the solution's applicability, which corresponds to step 6 and finally, the conclusion presents the theoretical contribution of the solution, relative to step 7.

2.2 Literature Review

Continuous improvement is the central element of several management concepts (Berger, 1997; Caffyn, 1999; Bhuiyan & Baghel, 2005; Albright & Lam, 2006), therefore, the literature review will be concentrated around the approaches that have been applied to process levels in indirect areas. Recently, approaches such as value stream mapping, analysis and design (Keyte & Locher, 2004), key performance indicator trees (Donko, 2012) and 5/6S (Schuh et al., 2013) have been applied in indirect areas, however, the application of these methods do not appropriately consider the cause-effect correlations and interdependencies between indirect processes. Magenheimer et al. (2014) stress that these interdependencies and correlations need to be taken into account in order to have an accurate and holistic view, however this mapping can become very complicated with large organizations. Moreover, the influence of these interdependencies and correlations are often difficult to quantify, additionally, improvements, for example lead time do not necessarily result in numerable financial improvements (Ozawa, 2007; Schloske & Thieme, 2010). Consequently, these approaches are difficult to apply to determine financial improvement targets in planning processes.

For financial improvement planning, ABM is often applied (Turney, 1992; Cooper et al., 1992). The concept of ABM originally emerged in the area of management accounting, but found its way into other fields of research, for example production research (e.g. Hsu & Su, 2005). Activity-based costing (ABC), an integral part of ABM, helps to both identify activities and processes that have the potential for improvement and to track these improvements (Collins, 1994; Cagwin & Bouwman, 2002). To identify such potential and set up target cost levels, reference activities/processes are required to be set in comparison to each other. This requires either a simple performance comparison in a benchmarking exercise (Delpachitra, 2008; Gleich et al., 2008) or the use of more advanced analytical methods, such as the data envelopment analysis (Kantor & Schlomo, 1999; Mota et al., 1999; Homburg, 2001). The drawback with benchmarking is that comparison data, especially external data, is not always available (Delpachitra, 2008). Furthermore, even if data is available (whether activity based or not), the comparability is questionable as to whether it would identify waste and allow continuous improvement in indirect areas (Magenheimer et al., 2014). As a result, generated benchmark figures in indirect areas may not necessarily highlight the best actions for improvements (Lee & Covell, 2008). Alternatively, in determining aspired cost levels, target costing as a method of enhancing continuous improvement (Albright & Lam, 2006) is considered as an interesting supplementation. Primarily used in product development research, target costing is applicable in both processes (Cooper & Chew, 1996) and indirect areas (Cooper & Slagmulder, 1997). Some authors, for example, Horváth et al. (1998) and Lockamy and Smith (2000) have suggested merging ABM and target costing. This combination seems legitimate as the idea of target costing is of particular interest in both high technology and labor-intensive industries, where indirect processes are key. The VCC, a tool used within target costing, can also be used to set financial targets. In using the VCC, the value of each element considered has to be determined first. To do this, approaches such as cause-effect diagrams are used for indirect areas (Chen & Chung, 2002), however, the disadvantage of this method is again the difficulty in applying the appropriate evaluation of correlations between indirect processes, taking into account their complexity, individuality, level of transparency and interdependencies. This is why ANP, a multi-criteria decision method, which enables the priority values of alternatives with interdependent correlations to be identified, is of interest. ANP has a wide range of applications (see review of applications in Hülle et al., 2013) and its use is expected to increase in importance (Sipahi & Timor, 2010).[11] In the context of indirect processes, Akman and Okudan (2009) used the ANP to design a performance monitoring model to enable the continuous improvement of the product development process. Van Horenbeek and Pintelon (2014) used ANP to develop a maintenance performance measurement framework to encourage continuous improvement. ANP outputs have also been combined with activity-based cost, for example, Tsai et al. (2010) developed a multi-step method for the selection of social responsibility programs in the hotel industry, while Shih-Jieh (2011) developed a model in combination with other methods to support the planning of production allocation for enterprises in a risky global market. These approaches do not enhance a financial target setting for indirect processes, therefore, this paper aims to bridge the gap by integrating ABM and the VCC with ANP.[12]

2.3 Methodology

The methodology is based on activity-based cost and ANP data, which are input to the developed target costing approach. The TSIP proceeding is composed from several steps as shown in Figure 2.1 (with the output of each step written on the outgoing arrow). Once the problem is defined, the processes are modeled in step I. Modeling processes are often described as the first and most important step towards making a rational decision. The modeling exercise transforms ill-defined processes into a set of well-defined elements, relations and operations (Ishizaka & Labib, 2014). The result of this structuring methodology is a better understanding of the process. This in turn acts as a prerequisite, or input, for subsequent methodologies used in the proposed integrated approach. In step II the attached costs of each process are identified, while in step III ANP is used

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11 For a more detailed description of ANP see Appendix 2.7.2.

12 After the paper was handed in at the ISAHP2014, suggestions by Belkin (2011) to use AHP and VCC in combination were found in the literature. These are two established decision-support methods in research discussions. However, the idea outlined can clearly be delimited from the TSIP method. The approach deals with the value and costs of functions, not with processes, and comprises AHP not ANP, while it does not address how to examine necessary analysis at all. It also suggests using a conventional VCC without an option for target derivation. Furthermore, why the idea had been developed and the origins of the idea were not stated.

to determine the contribution level of each alternative in order to reach the main goals of the direct core process, as well as determining the ability level of each alternative to realize improvements. In step IV a VCC, adapted for the purpose of the method, is then used to derive concrete cost improvement goals based on activity-based costs. By combining these methods, the limitations of each single method, listed in Table 2.1, are counterbalanced by strengths of others in respect of the research target.

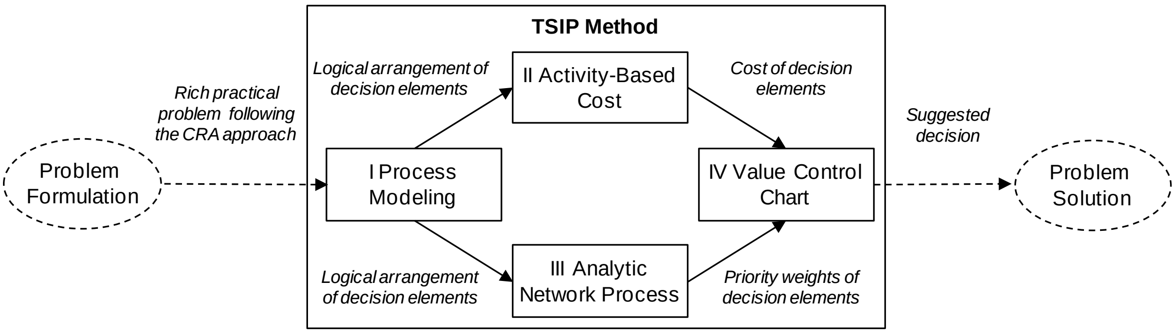


Figure 2.1: Schematic method development (own illustration)

	Strengths	**Limitations**
Processes modeling	The structure of the problem is recorded in a systematic and comprehensive approach.	The method is not prescriptive, it is rather descriptive.
ABC	Efficiency gains can be tracked over time.	Sheer costs do not allow an indication of efficiency potentials.
ANP	Qualitative and quantitative elements are prioritized with the consideration of interdependencies between them.	Generated priorities do not allow target derivations.
VCC	Possible derivation of targets and consideration of subsidization as well as capacity of improvement by the flexible extension of a primary visual method.	The underlying approach is a simplified value to cost efficiency determination, blanking out other factors.

Table 2.1: Core strengths and limitations of the methods used (own illustration)

I Processes Modeling

The main goal of process modeling is to develop a formal representation of the contributory factors in the decision problem, including the views, opinions and values of multiple decision-makers. Process modeling is not a solution-oriented approach, but an approach to finding the constituents of the process (Ishizaka & Labib, 2014). A popular way to structure the processes is the component-based approach, which leads to more manageable activities in the TSIP method. This step has five phases:

I.I Identification of direct core process: A direct core process generates value to the external customer, however, the improvement possibility will not be analyzed. The listing is only necessary to identify the relevant indirect processes in the following.

I.II Identification of indirect processes: All indirect processes $p \in P$ that increases the internal, and indirectly as a result, the external customer value is identified.[13]

I.III Indirect processes structuring: Each indirect process p can be broken down into activities $a \in A$ (each activity belongs to only one process). If not indicated otherwise in all following equations $\forall\, p \in P \;\; \forall\, a \in A_p$ applies. When the number of indirect processes or respective activities is high, which is often the case, it is advised to group them into clusters to facilitate the analysis, for example, forming main processes based on specific process characteristics.

I.IV Identification of the evaluation criteria: The indirect processes are evaluated on criteria (and possible sub-criteria), based on the characteristics of the core process, as well as the customer requirements. The criteria have to express the value contribution to the direct core process and the capacity to improve.

I.V Identification of interdependencies: As indirect processes may not only add value to the direct process but to other indirect processes and vice versa, all interdependencies must be identified.

II Activity-Based Cost

The idea of ABC is to manage activities and processes by allocating costs to those consuming resources based on their corresponding cost drivers. These are determined by the frequency of the execution of the activities and processes (Johnson, 1988). Activities, irrespective of the department, are aggregated to processes with a defined output valued by the customer (Davenport, 1993). The clustering is generally done on activity-based data, i.e. all activities with the same cost driver are aggregated. If ABC is extended with process management information, an ABM tool is created (e.g. Cooper et al., 1992). ABM attempts to help on an operational basis to increase efficiency by performing the same activities with fewer organizational resources (Kaplan & Cooper, 1998). After having identified the cost c_a of each activity a, it is multiplied by the driver d_p of process p to find the drifting cost DC_a for a given period where.

$$DC_a = c_a \cdot d_p \qquad (1)$$

The drifting cost information is then used in an adapted VCC, discussed in step IV.

13 All notations and symbols used in this chapter can be found in an overview at the end of this thesis.

III Analytic Network Process

The execution of ANP can be done in parallel to step II as it relies on the output of step I. ANP is the general form of the Analytic Hierarchy Process (AHP), and were both introduced by Saaty (2001).[14] In the following a short description of ANP is given based on van Horenbeek and Pintelon (2014). The main difference between the two methods is that AHP has a hierarchical structure and ANP is based on a network structure. The adopted structure depends on the modeling of the problem, for example, a hierarchical structure is a linear top-down relationship with no feedback from a lower to a higher level, while the network structure is composed of different elements and clusters (groups of elements) that are connected to each other. The network structure can have connections between any factors in the decision problem. These connections represent the different relationships that exist between the clusters and the elements in the decision problem. Different relationships (inner dependence, outer dependence, feedback) exist between the clusters and its elements. The directions of the arrows in the network structure are important because they represent the relationship between two clusters. The goal of the decision problem is to find, based on the network structure designed by us, the processes and activities that are the most appropriate for improvement. For this purpose, pairwise comparisons between the different clusters and elements are performed to derive the priorities of all activities and processes under each criterion. Two key measures are the value contribution x_a of the activity a and its capacity to be improved y_a. These two values are not directly combined as they have different scales and will be processed in step IV in an adapted VCC.

IV Value Control Chart

The output of steps II and III become the inputs for the adapted VCC. A VCC is used to identify processes that need improvement in order to reach the superior target cost level (Glaser, 2002). The fundamental assumption is that the maximum affordable cost of an element is determined by its value contribution. Within the VCC the degree of importance is plotted on the x-axis and the percentage share of cost on the y-axis. The angle bisector is considered as the ideal line where the value contribution of each element matches with its costs (Tanaka, 1989). Elements above the angle bisector can be considered too expensive, which indicates a need for cost reduction. Elements below the angle bisector could be considered too simple, indicating a need for improvement in functionality (Wildemann, 2012). It is important to note that the absolute value needs to be used and not the relative value as in the initial VCC proposition, because reduction targets can otherwise be distorted (Brühl, 2010).

As most firms start improvement projects triggered from outside competition, the question is: How are these improvements reached with minimum effort? To address this question, the VCC is adapted and further developed by us in the following step, which has two phases. In order to

[14] See Appendix 2.7.3 for a detailed description how ANP is designed and examined.

determine the target cost level of each activity and process, the aspired superior cost reduction goal *G* is defined by the market competition.

IV.I Subsidization effect: It is assumed that production is already efficient on its value stream but not in its costs. This means that there is no redundant indirect process and the value contribution toward the direct process is already optimal. Therefore, the processes and activities below the angle bisector shall indirectly subsidize those above, which are more expensive. As a result, only activities and processes above the angle bisector need to be considered for improvement, but in a reduced capacity because they are partially subsidized by the ones below the angle bisector. The exact cost reduction required is calculated as follows: The allowable costs AC_a for each activity *a* belonging to process *p* are proportional to the value contribution x_a calculated with ANP (step III).

Therefore, AC_a is given by the total drifting costs DC_a of all activities minus the reduction goal *G* multiplied by the normalized value contribution x_a:

$$AC_a = x_a \cdot \left[\left(\sum_{p \in P} \sum_{a \in A_p} DC_a \right) - G \right] \tag{2}$$

The difference between the drifting cost and allowable cost gives the target cost reduction t_a:

$$t_a = \begin{cases} DC_a - AC_a & \text{if } \frac{DC_a}{AC_a} > 1 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

As the costs of the activities and processes below the angle bisector will not be increased, this partially compensates for the allowable costs above the diagonal (i.e. they can be higher). The subsidizing factor *s* indicates the level to which degree the efficient activities below the angle bisector will contribute to reduce the reduction need of those above and is given by:

$$s = \frac{G}{\sum_{p \in P} \sum_{a \in A_p} t_a} \tag{4}$$

The subsidized target cost reduction s_a is given by:

$$s_a = \begin{cases} s \cdot t_a & \text{if } \frac{DC_a}{AC_a} > 1 \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

The subsidized allowable cost sAC_a of activity *a* is given by:

$$sAC_a = DC_a - s_a \tag{6}$$

In the case, where all drifting costs are larger than their allowable costs, all elements require cost reductions and the sAC_a is equal to the AC_a. By consequence, the subsequent consideration of capacity described below is irrelevant.

IV.II Capacity consideration: Cost reduction is not always a straightforward task and not all processes and activities have the same ability to adapt. It is therefore necessary to incorporate the capacity of the activity to improve y_a calculated with ANP (step III) in the target cost reduction. To determine the target cost reduction p_a considering the capacity of improvement, some pre-calculations are required. In particular, it is necessary to ensure that the target cost reduction is not shifting the allowable costs with capacity consideration above the current drifting costs or below the allowable costs.

For this purpose, the minimum distance lu_a between these two thresholds for each activity needs to be calculated:

$$lu_a = min\ \{(sAC_a - AC_a);(DC_a - sAC_a)\} \tag{7}$$

As in the following only those activities above the angle bisector should be considered, the equations (8)–(14) apply $\forall\, p \in P\ \ \forall\, a \in A_p$: $DC_a / AC_a > 1$. Consequently, the priority values y_a of the considered activities above the angle need to be normalized (z_a):

$$z_a = \frac{y_a}{\sum_{p \in P} \sum_{a \in A_p} y_a} \tag{8}$$

The consideration of the capacity of the activities should neither increase nor decrease the total reduction requirements. To ensure this, the extent to which each activity should be adapted has to be leveled. This is done via the use of q, λ_a, δ_a, α_a and β_a as well as the mean of all z_a ($\bar{z}$):

$$q = \begin{cases} \dfrac{\sum_{p \in P} \sum_{a \in A_p} \alpha_a}{\sum_{p \in P} \sum_{a \in A_p} |\beta_a|} & if\ \ \sum_{p \in P} \sum_{a \in A_p} \alpha_a \leq \sum_{p \in P} \sum_{a \in A_p} |\beta_a| \\ \dfrac{\sum_{p \in P} \sum_{a \in A_p} |\beta_a|}{\sum_{p \in P} \sum_{a \in A_p} \alpha_a} & otherwise \end{cases} \tag{9}$$

$$\lambda_a = \begin{cases} \dfrac{\alpha_a \cdot q}{lu_a} & if\ \ \sum_{p \in P} \sum_{a \in A_p} \alpha_a \leq \sum_{p \in P} \sum_{a \in A_p} |\beta_a| \\ \dfrac{\alpha_a}{lu_a} & otherwise \end{cases} \tag{10}$$

$$\delta_a = \begin{cases} \dfrac{|\beta_a| \cdot q}{lu_a} & if\ \ \sum_{p \in P} \sum_{a \in A_p} \alpha_a \leq \sum_{p \in P} \sum_{a \in A_p} |\beta_a| \\ \dfrac{|\beta_a|}{lu_a} & otherwise \end{cases} \tag{11}$$

where

$$\alpha_a = \begin{cases} (z_a - \bar{z}) \cdot lu_a & if\ (z_a - \bar{z}) > 0 \\ 1 & if\ (z_a - \bar{z}) = 0 \\ 0 & if\ (z_a - \bar{z}) < 0 \end{cases} \tag{12}$$

$$\beta_a = \begin{cases} (z_a - \bar{z}) \cdot lu_a & if\ (z_a - \bar{z}) < 0 \\ 1 & if\ (z_a - \bar{z}) = 0 \\ 0 & if\ (z_a - \bar{z}) > 0 \end{cases} \tag{13}$$

The highest value from the λ_a and δ_a (14) is then used to calculate the costs reduction considering the capacity of the activity (15) with the help of k.

$$k = max\ \{ \lambda_a\ ;\ \delta_a \} \tag{14}$$

$$p_a = \begin{cases} s_a + \frac{\lambda_a\ -\ \delta_a}{k} \cdot lu_a & if\ \frac{DC_a}{AC_a} > 1 \\ 0 & otherwise \end{cases} \tag{15}$$

Finally, the allowable cost considering capacity pAC_a of activity a is given by:

$$pAC_a = DC_a - p_a \tag{16}$$

Each activity a has its own target cost level pAC_a calculated. For those activities initially located above the angle bisector, this represents a higher value-/cost-efficient level, taking into account the capacity of these activities to reach such improvements. If all activities achieve this target, the total reduction goal G is achieved.

VCC is best represented in a graph due to its visual representability. Figure 2.2 shows an adapted SC-VCC (subsidization and capacity considering VCC) based on example data in Table 2.2. As already pointed out, all activities do not change their value contribution as they are already assumed to be optimal on this axis, therefore the shifting will be only on the vertical axis. Activity 2.1 is below the angle bisector, therefore its drifting cost is equivalent to its subsidized allowable cost and allowable cost with consideration of capacity. In other words, activity 2.1 does not need any costs improvements, and as a result this activity subsidizes the cost reduction need of all activities above the angle bisector. This effect is shown in Figure 2.2 by movement A (the distance of all activities above the angle bisector between the DC_a and the sAC_a is smaller than between the DC_a and the AC_a positioned on the angle bisector). Activity 1.1 is the activity that has the highest cost reduction need (t_a and s_a), which is even increased (p_a) due to its high capacity to implement this cost reduction compared to the capacity of all other activities above the angle bisector.

This effect is visualized in Figure 2.2 by movement *B*. The SC-VCC allows the derivation of the reduction need, which represents distance *d*.

activity	*process*	*value contri-bution*	*capacity for improve-ment*	*drifting cost*	*allowable cost*	*target cost reduction*	*subsi-dized target cost reduction*	*subsi-dized allowable cost*	*target cost reduction consi-dering capacity*	*allowable cost consi-dering capacity*
a	p	x_a	y_a	DC_a	AC_a	t_a	s_a	sAC_a	p_a	pAC_a
1.1	1	0.05	0.40	28.00	3.50	24.50	16.90	11.10	20.10	7.90
1.2	1	0.20	0.35	21.00	14.00	7.00	4.83	16.17	5.35	15.65
2.1	2	0.35	0.15	11.00	24.50	0.00	0.00	11.00	0.00	11.00
2.2	2	0.40	0.10	40.00	28.00	12.00	8.28	31.72	4.55	35.45
	∑	1.00	1.00	100	70	43.50	30	70	30	70

Table 2.2: Example of calculations for the SC-VCC (own illustration)

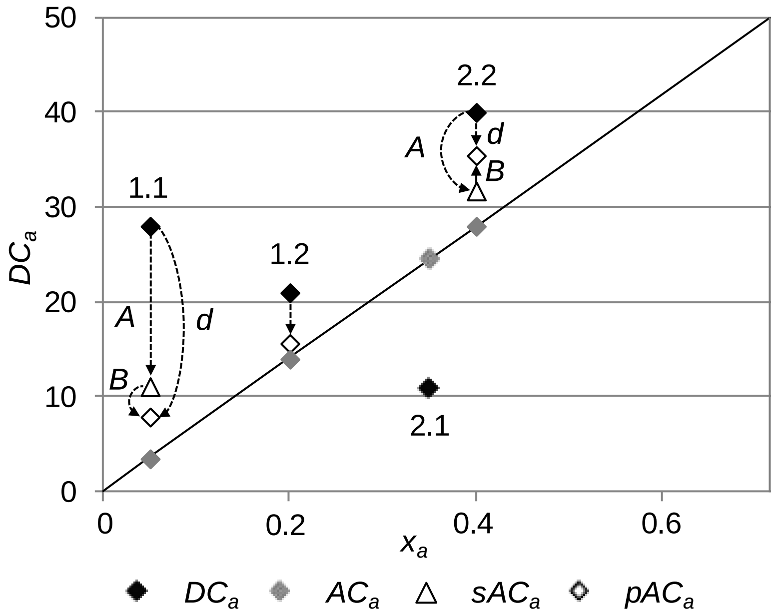


Figure 2.2: Adapted SC-VCC with data from Table 2.2 (own illustration)

2.4 Case Study

The implementation of the TSIP approach proposed in section 2.3 is an important step within the CRA, because it validates the analytic model building (Lukka, 2000; Lukka, 2002; Labro & Tuomela, 2003). The aim is to examine whether the method works technically and smoothly (Lukka, 2000). The cooperating organization is a global first-tier automotive supplier. The automotive industry is regarded as a pioneer in many fields and is driven by a large share of indirect processes as well as significant cost pressure (Moritz & Heiss, 2012; Stolz & Berking, 2013; Roland Berger, 2014). The unit in focus is a national EFQM-Award winner plant, certificated by ISO/TS 16949 (based on ISO 9001 including continuous improvement). The cooperating organization and specifically the studied site have already gained experience in process improvements in indirect areas: tools such as value stream mapping, analysis and design or 5/6S are used on a regular basis to improve indirect processes. They are, however, struggling to identify areas of improvement within budgeting processes from a management perspective, and as a result, the company asked the authors of this paper to develop a method for better identifying indirect process to improve and to what degree.

The implementation of the TSIP method was realized in a three-stage approach as shown in Figure 2.3. In the first implementation stage, the four steps of the TSIP method were implemented. At the end of the first stage, the indicated processes for improvements were presented to senior management, where continuation of the project was approved. Steps II and IV were rerun with the updated cost information and following another presentation with the possible improvement indications, the senior management and board of management decided that the use of this method should be pursued and become an integral part of the yearly tactical planning process (3.a). Furthermore, the TSIP method has recently been used for planning and management actions to identify improvement potentials with the ultimate goal of maintaining the competitiveness of the cooperating plant over the course of the year (3.b). For this reason, the TSIP method can be interpreted within kaizen budgeting as a method of enhancing continuous improvements on a regular budgeting basis. Kaizen budgeting has to be distinguished from budget cuts as it not only follows external triggers but anticipates and encourages efficiency gains ex-ante (Blocher et al., 2010). The TSIP method is now used regularly within the yearly rolling tactical planning process at the cooperating organization, replacing previously used budget allocation methods (see Chapter 2.5 for a discussion and evaluation of the implementation success in Figure 2.7).

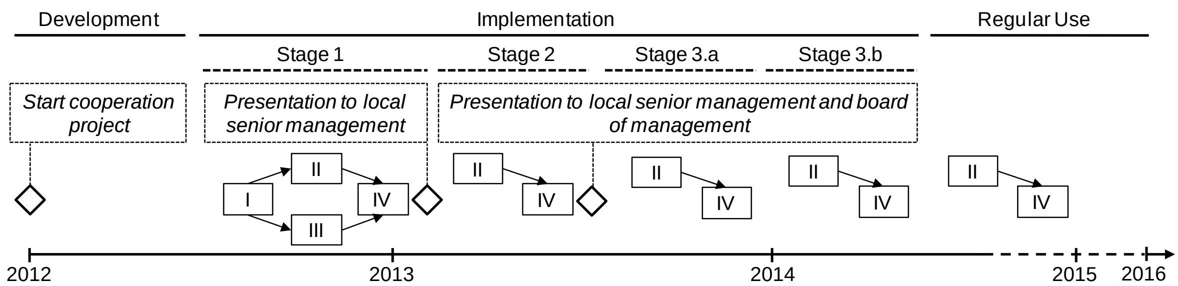


Figure 2.3: Implementation stages of TSIP (own illustration)

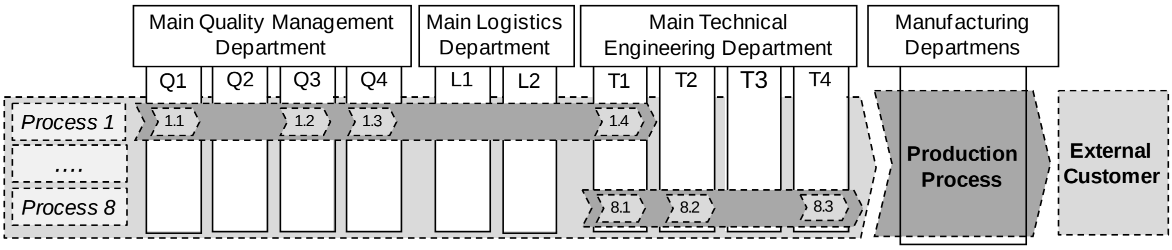
In the following it is described in detail how each step of the TSIP method was performed at the case organization.

I Processes Modeling

<u>I.I Identification of direct core process</u>: The production process was defined as the direct core process. The manufacturing departments were retained as the internal customer.

<u>I.II Identification of indirect processes</u>: Eight indirect processes operated by ten departments clustered into three main departments (quality management, logistics and technical engineering) were identified as internal service supplier. The definition of the internal customers-supplier relationship was communicated in the context of an already existing consumption-based production strategy and as a result, the concept was readily accepted by the managers involved who were signed off as evaluating experts in ANP.

<u>I.III Indirect processes structuring</u>: The eight indirect processes were deconstructed into 83 activities. The scheme of the process model and activities is shown in Figure 2.4.[15]



Q1: Department for product quality securing *Q2: Department of customer management*
Q3: Department for quality and method management *Q4: Department of material analysis*
L1: Department of production planning and control *L2: Department of physical logistics*
T1: Department of manufacturing methods and tooling technology *T2: Maintenance department*
T3: Industrial Engineering department *T4: Resource Management department*

Figure 2.4: Scheme of the process and activity model (own illustration)

<u>I.IV Identification of the evaluation criteria</u>: First, a literature review (Table 2.3) was conducted on the factors used to evaluate the performance of processes in the cooperation case context.

	Flexibility	Delivery	Quality	Cycle time	Excess	Availability
Ramkumar et al., 2009	x	x				
Behrouzi & Wong, 2011	x	x	x			
Öztayşi & Sari, 2012	x	x	x	x		x
Schoenherr et al., 2012	x	x	x			
Wong & Wong, 2007	x	x		x		
Johnson,1988	x	x	x	x	x	

Table 2.3: Importance criteria from the literature (own illustration)

[15] For design reasons, further in-between clusters have been required in the ANP analyses in the case study.

The senior managers of the cooperating company have selected the criteria *quality*, *delivery*, *ability to change* (flexibility), *failure cost reduction* (availability and excess) and *cycle time reduction* as they are applied on a regular basis in the cooperating plant. These criteria confirm the findings from the literature review, even if other terminology has been used.

I.V Identification of interdependencies: All department managers in charge of at least one activity assigned to a process had to identify the inner dependence of all activities of such processes under each criterion in a brainstorming session. As several interdependencies have been identified by different managers, the necessity of ANP, which take them into account, was demonstrated.

II Activity-Based Cost

In the first two stages of the development of the TSIP method, the indirect departments were actively supported in order to determine the activity-based costs ex-post with the support of management from the accounting department. From stage 3.a onwards the departments were allocating their resources to the performed activities and processes themselves based on the information provided by the accounting department.

III Analytic Network Process

The ANP network (Figure 2.5) was designed in SuperDecisions.[16]

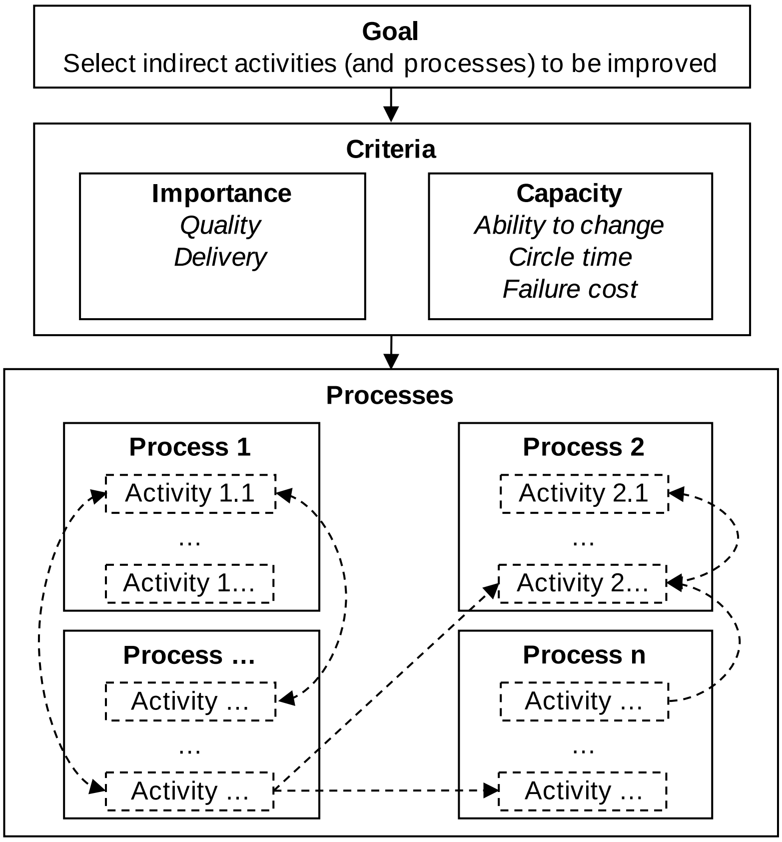


Figure 2.5: Network design (own illustration)

The evaluation is as follows: the processes were evaluated by five senior manufacturing main department managers and five senior plant managers because they had a macro view of all processes. The evaluation on activity level was carried out by the respective department managers (quality management, logistics and technical engineering) in charge of at least one activity clustered under one process and the respective interdependencies. Each manager gave their evaluation independently and were briefed in a 30-minute meeting on understanding the evaluation of the pairwise comparisons questionnaire. The questionnaire was then sent to each manager requesting a timely response (average response rate of two weeks, with some individual delays requiring a further request).

If the consistency ration (*CR*) was larger than 0.1 on the activity level, the evaluating managers were asked to revise their judgments until consistency was reached. Their judgments were aggregated in a group decision process with a geometric mean, which is the method of choice (Saaty, 2006; Saaty, 2008; Saaty & Vargas 2012). On the process level, the organization decided that the

16 We are grateful to Rozann Whitaker Saaty for her advice on using SuperDecisons.

senior managers were not to receive a revision request if the consistency ratio was larger than 0.1 due to the limited time available. As a result, their judgments were aggregated with a weighted geometric mean. More specifically, a high inconsistency ratio was interpreted as an indicator of a lack of coherent understanding of the evaluated processes (Cho & Cho, 2008). The weights *w* were assigned as following: $CR < 0.1$: $w = 3$; $0.1 < CR < 0.2$: $w = 2$; $0.2 < CR < 0.3$: $w = 1$; $CR > 0.4$: $w = 0$. In total, 163 matrices, with 4578 pairwise comparisons, were completed by the 20 managers.

IV Value Control Chart

An SC-VCC was designed for all stages as the cost data changed over time.

IV.I Subsidization effect and IV.II Capacity consideration: An extract of real case data from stage 3.a of the implementation process at the cooperating plant is shown in Table 2.4. The planned drifting costs of 56.6 million EUR shall be reduced by 5% (G = 2.8 million EUR).

a	p	x_a	y_a	DC_a	AC_a	t_a	s_a	sAC_a	p_a	pAC_a
…	…	…	…	…	…	…	…	…	…	…
6.1	6	.0009	.0146	1.443	46	1.397	147	1.296	200	1.243
6.2	6	.0032	.0146	665	169	496	52	613	71	594
6.3	6	.0048	.0146	2.660	258	2.402	253	2.407	344	2.317
6.4	6	.0007	.0146	591	35	556	59	532	79	511
6.5	6	.0008	.0146	369	43	326	34	335	47	322
6.6	6	.0008	.0146	484	40	444	47	437	63	421
6.7	6	.0008	.0146	419	40	378	40	379	54	364
6.8	6	.0092	.0146	3.662	492	3.170	334	3.328	453	3.208
…	…	…	…	…	…	…	…	…	…	…
7.1	7	.0217	.0069	1.088	1.163	0	0	1.088	0	1.088
7.2	7	.0335	.0083	1.340	1.798	0	0	1.340	0	1.340
…	…	…	…	…	…	…	…	…	…	…
	∑	1.00	1.00	56.567	53.738		2.800	53.738	2.800	53.738

[costs in kEUR]

Table 2.4: Extract of calculations for the SC-VCC of stage 3.a (own illustration)

The drawing of the VCC is shown in Figure 2.6 as well as the SC-VCC with cost measures on both axes (which facilitates the direct derivation of the required reduction targets of ach activity from the chart). Activities allocated below the angle bisector (for example activity 7.2) help to subsidize the reduction need of all activities allocated above the angle bisector in the first step of subsidization (shown as the movement *A* of activity 6.8 in the right figure, representing $sAC_{6.8}$ = 3.328 kEUR). In the next step the potential of activity 6.8 and all other activities above the angle bisector are considered. The reduction need of activity 6.8 is $p_{6.8}$ = 453 kEUR (read from Table 2.4), which is the vertical distance between $pAC_{6.8}$ = 3.208 kEUR (point *B* in the left figure) and the angle bisector. As activity 6.8 has a higher capacity to improve its cost position ($y_{6.8}$ = 0.0146) than the average of all activities above the angle bisector ($\bar{z}$= 0.0118), $pAC_{6.8}$ is smaller (positioned closer to the y-axis) than $sAC_{6.8}$ (causing a larger distance to the angle bisector, shown as the movement *B*).

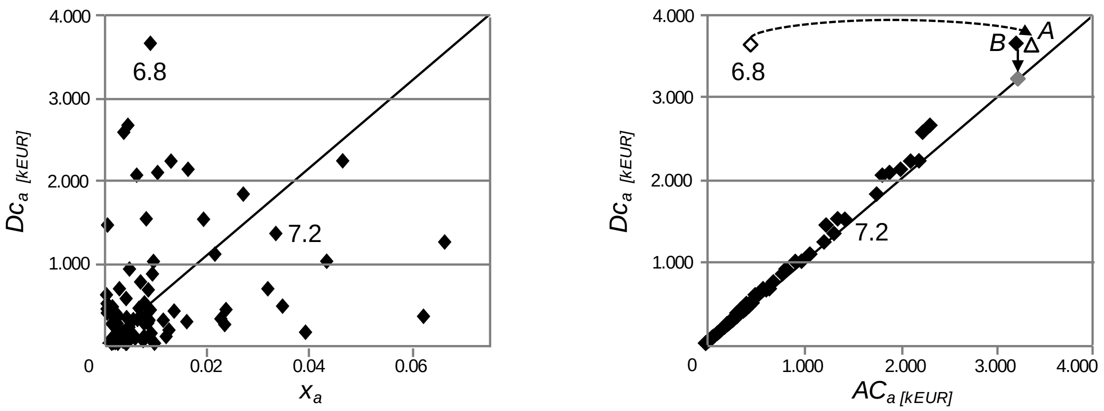


Figure 2.6: VCC of implementation stage 3.a (left side) in comparison to SC-VCC with cost measures on both axes (right side) (own illustration)

The display of the results in a management cockpit, which allows the management of the cooperating plant to process the data individually as demanded, is of specific interest. Based on the cockpit, it is possible to derive reduction goals for:

- each senior manager in charge of one main department,
- each manager in charge of a department,
- each process covering different departments,
- each activity complemented by the information on how to reach the reduction goals.

Different variants for reaching the reduction goal may be considered: reduction of the driver at the same cost of activity, reduction of the cost of activity at the same driver or a combination of both.

With respect to the usage of the TSIP method in the budgeting process, the target derivation found specific attention on the department level because budgets are allocated on this level in the cooperating organization. Nevertheless detailed discussions based on the outcomes of the TSIP method were also observed on a process and activity level between the managers of the indirect processes and their colleagues from the manufacturing departments.

2.5 Discussion

In the following discussion, the developed TSIP method is evaluated with regard to its novelty and potential field of application with the assistance of the CRA market test, as well as expert evaluations. Furthermore, potential limitations of the method are discussed, as are ways these can be addressed in future research.

Scope of the solution applicability and managerial implication

To examine the applicability scope of the developed method and to ensure the validity of the research, a differentiated market test was applied (Lukka, 2000; Labro & Tuomela, 2003). The market test gets stronger if a construct moves towards the upper-right-hand corner of the market test evaluation table shown in Figure 2.7. The X in Figure 2.7 illustrates the unequivocal weak market test status that the TSIP method at the cooperating plant reached, because it is positioned above the dotted market test border. The dotted X demonstrates the desired usage of the TSIP method in additional plants and possibly the whole corporate group. The intention to further roll out the method, which is thought to be a chance to break up the recent 'black box' character of indirect processes, was announced by another plant manager as well as a member of the board of management. The superior expectation by rolling out the TSIP method is to strengthen the market competitiveness of the corporate group as market powers require reduced sale prices and high levels of quality and delivery at the same time.

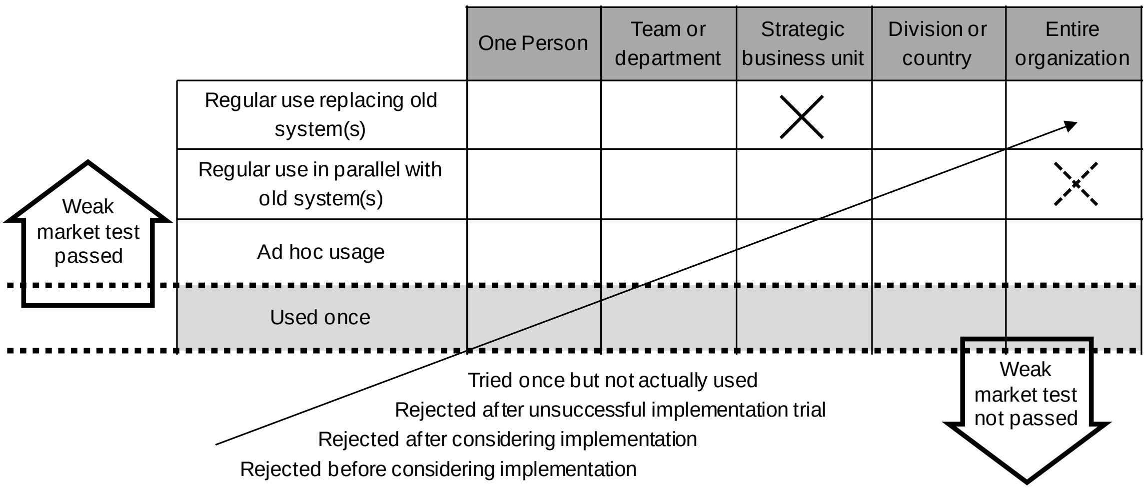


Figure 2.7: Dimensions of weak market test (based on Labro & Tuomela, 2003)

In addition to passing the market test confirming the relevance of TSIP, the universal characteristic of the method should be pointed out, facilitating an application of the method in alternative settings. Additionally, it can be assumed that the management of the cooperating plant has comprehensive knowledge of the possibilities and drawbacks of tools to manage continuous improvements in indirect processes: besides being a national EFQM award winner and ISO/TS 16949 certified first-tier automotive supplier plant, they set up benchmarking activities with competitors, customers and consulting firms on a regular basis. The perception among the benchmarking partners is that the operative realization of improvements in indirect processes is no longer the crucial challenge (even some less experienced organizations might not be able to do so), but rather the facilitating of the identification of areas for improvement from an aggregated management perspective. Yet proclaimed approaches lack the incorporation of planning functionalities (e.g. value stream mapping), simplify the selection process (Pareto-analysis: focusing on the largest cost causing processes) or do not allow concrete derivations (if for example benchmarking figures are available, they are commonly aggregated on a high-level; e.g. average share of logistic costs of total product costs in an industry). Therefore the positive evaluation of the TSIP method from the vice president shall be highlighted and the method enhanced and diffused in academia and practice.

Limitations

One of the key points is that the evaluation from the managers is relied on. They were able to artificially increase the priorities of the processes they were in charge of by adding more interdependencies. This was, however, necessary to extract such interdependencies, taking into account the complexity of the examined activities and processes, but as the interdependencies were identified by multiple managers, they were crosschecked and the process modeling found to be robust.

The priority values of the alternatives are only valid in the context of continuous improvement: Radical cost reductions might require a redesign of the processes, making the process structure and evaluations obsolete. In such a situation, a new examination of the TSIP method would be required.

The number of required pairwise comparisons may be high in reality, as with the cooperating plant. To overcome this problem, further aggregation cluster levels can be set up and evaluated by different experts to reduce the comparison effort of the single experts.

For the gathering of the cost information, the ‘classical’ ABC has shown its suitability at the cooperating plant. Depending on the specific organizational circumstances of potential further users of the TSIP method, recently discussed approaches such as time-driven ABC (Kaplan & Anderson, 2004; Hoozée & Bruggeman, 2010) might help to overcome potential challenges in collecting cost information, caused, for example, by the absence of respective calculation elements in the reporting structure of an organization.

The definition of a value-to-cost ratio of 1 within the VCC, derived from the idea that the customer only pays for what they really need as being cost efficient, leaves aside other possible improvement gains. The activities and processes below the angle bisector could perhaps also contribute to reaching superior target cost levels. In this case, it should be considered going against the philosophy of the VCC, where elements below the angle bisector should actually increase their costs. Furthermore, the aim of the TSIP method is to give managers a tool that enables any organization to reach a desired cost-efficient level in indirect processes, with appropriate efforts: after the reduction targets are derived the operational improvements of the business processes have to be initiated. If they were initiated for all examined processes at the same time, significant efforts might be required, potentially leading to a resistance within the affected departments.

2.6 Conclusion

The priority values of all indirect activities and processes resulting from ANP allow the derivation of concrete reduction goals based on activity-based costs within the use of an adapted VCC. As a result, the TSIP method goes beyond the simple selection of processes to be improved and therefore goes a step further than previous ANP studies. The TSIP method contributes to the body of research on the use of the ANP in the context of performance measurement, thereby allowing unique insights, representing an advanced decision-making basis for managers to decide how to allocate cost reduction targets in indirect areas. This has not been possible to such an advanced level with any other approach before. Studies discussing the possibility of improving indirect areas do not either appropriately address the decidedly information requirements in indirect processes to identify starting points for improvements (e.g. benchmarking or key performance indicator tees) or incorporate adequate planning mechanisms (e.g. value stream mapping, analysis and design or 5/6S). The use of approaches primarily developed for application in direct areas are not always appropriate, as indirect processes are driven by high levels of interdependencies, common low levels of transparency, insights and intangible information that are the major source of exchange between them. As a consequence companies trying to determine improvement targets for indirect processes predominantly focus on the main cost affecting processes or set up uniform targets for all processes, neglecting individual process efficiency levels.

This study has demonstrated that ANP can be applied to a very large project. It is true that a high number of activities to compare leads to a high number of pairwise comparisons, however, not all managers were experts in all processes and as a result, their evaluation was requested solely for their domain of expertise, making the process manageable. The incorporation of several evaluations from different people leads to a group decision process. In this case the participants did not interact but interaction could be considered in future work in order to incorporate a negotiation stage for contradicting evaluations.

As all managers of the considered indirect processes and the senior managers of the manufacturing departments as well as further senior managers were involved in the evaluation process, the derived management implications were given a wide approval. Furthermore, due to the gained transparency insights, factual driven negotiations, between the managers at the cooperating plant, within budgeting processes have been observed. Before the implementation of the TSIP method, negotiations within budgeting processes were often described as driven by internal political preferences and individual negotiation skills of the respective managers. All these gained insights may open the door for a broader field of application of ANP in organizational research.

In this case the developed TSIP method was used for cost reduction where the quality and delivery ability was assumed to already be at its optimum. The TSIP method could also be used by inverting the variables: the costs are at their optimum and the quality as well as delivery ability of the processes needs to be improved. The TSIP method was primarily designed to analyze indirect processes, however, applying the method to analyze direct process improvements is also possible.

2.7 Appendix

2.7.1 Steps of the Constructive Research Approach

The seven steps of CRA have been further clustered into three phases by Labro and Tuomela (2003). They also indicated the relative time required to perform each step as shown in Figure 2.8. The striped blocks of step 3 and 7 indicate the permanent, though not primary, focused examination of the steps by the researcher.

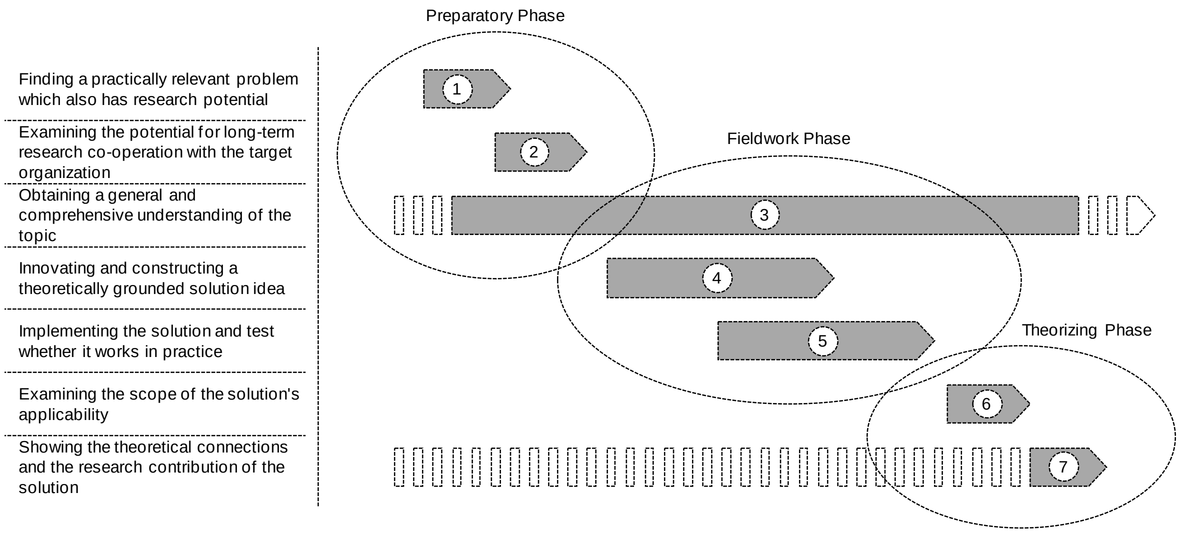


Figure 2.8: Phases and steps of CRA (own illustration based on Kasanen et al., 1993, Lukka 2000 and Labro & Tuomela 2003)

2.7.2 General Remarks on the Analytic Network Process

The ANP is, even though chronological introduced later, the general form of the well known AHP, both introduced by Saaty (Saaty, 1996; Öztayşi & Sari, 2012; Hülle et al., 2013) as multi criteria decision methods.[17] The method enables its user to determine priority values between alternatives to choose from. This is of great usage in many decision situations where the correlations between the alternatives can barley be determined with alternative approaches irrespective of the required efforts (for example forecasts in political elections) or in situations where the determination of correlations would require unproportional efforts. The ANP enables its user to transform implicit knowledge to explicit and to make accurate decisions (Saaty, 1999). The existing knowledge of the evaluating experts about the system is extracted with the help of pair wise comparisons between the elements of the decision system. In this context and in respect to critics about the accuracy and the relevance of this procedure the following core idea of the method shall be pointed out:

[17] Irrespective of the drawback of not being able to consider interdependencies, the AHP is still more often found in academic discussions (Siphai & Timor, 2010).

"Comparisons are not only mathematically necessary, but they are our heritage from our biology. Comparisons require judgments. Judgments are associated with feelings, feelings with intensities, intensities with numbers, numbers with a fundamental scale, and a set of judgments represented by a fundamental scale, with priorities" (Saaty, 2004a: 131-132). A very good overview of a recent ANP publication and its applications is given by Hülle et al. (2013) as well as Sipahi and Timor (2010). The ANP allows, unlike the AHP, the consideration of interdependences within the decision system which makes the method of high interest as it enables the user to design more realistic decision scenarios (Saaty, 2004a; Carlsson & Fullér, 1995).

2.7.3 Examination of an Analytic Network Process

In the following the process of how to undertake an ANP shall be described in four main blocks, explaining the underlying theoretical concepts (if not emphasized specifically the proceeding is based on Saaty, 1996; Maede & Sarkis, 1999; Chung et al., 2005; Yüksel & Dağdeviren, 2007):

1. Constructing the model and structuring the problem

The decision problem has to be designed in a way that it can be broken down into a network system. A network can be assumed as a system consisting of subsystems. Subsystems are made up from components respectively clusters which are made up by elements (Saaty, 2006). The system structure is determined in a more or less structured design process by the decision makers. For example, depending on the problem that should be solved, Saaty (2004b; 2006) suggests structuring a system with the help of the criteria: benefit, opportunities, costs and risks. Besides designing from scratch, a network could also be based on a hierarchy by connecting elements to pairs and setting inner dependence loops of clusters and elements (Saaty, 2006). The direction of the arrow indicates the direction of the dependency. The conceptual design of a network with clusters having inner and outer dependences among their elements and its difference to a linear hierarchy shall be demonstrated in Figure 2.9.

C_k: clusters of a decision system

$k = 1,\ldots,n$

each cluster k has m_k elements denoted by $e_{k1}, e_{k2}, \ldots, e_{km_k}$

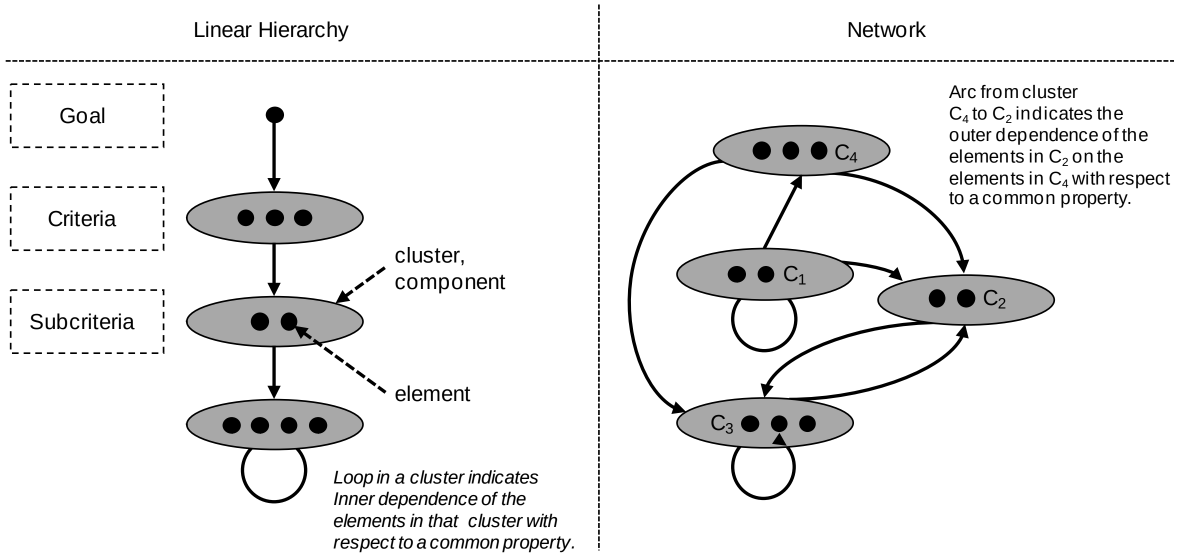


Figure 2.9: Conceptual design of a hierarchy and a network (based on Saaty, 2004a and Saaty, 2006)

2. Pair wise comparisons matrices and priority vectors

To determine the priority values pair wise comparisons are required. The decision maker has to evaluate two elements or clusters at a time under an upper level criterion in a pair wise comparison matrix. The comparison of them is done in respect of their relative importance towards the criterion. Furthermore, if interdependencies between elements and or clusters are detected, pair wise comparisons are required between them as well. The suggested scale from 1 to 9 to examine the comparisons, introduced by Saaty, has proven its validity in theory and practice (Saaty, 2006; Saaty & Vargas, 2012). The scores are recorded in a comparison matrix for the required calculations. A score of 1 indicates equal importance or indifference between the elements or clusters under the evaluating criteria, while 9 indicates an extreme dominance of one (row cluster in the matrix) compared to the other one (column cluster in the matrix). If an element or cluster has a weaker impact the range of scores is from 1/2 to 1/9, so the scale is reciprocal. Consequently, 1/9 represents an extreme dominance by a column element respectively cluster over the row element respectively cluster. The detailed grading and description of the scores can be found in Table 2.5.

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	*Weak*	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	*Moderate plus*	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	*Strong plus*	
7	Very strong demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	*Very, very strong*	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Table 2.5: Fundamental evaluation scale (based on Saaty, 2006)

When the scoring of a pair is done, the reciprocal value is assigned to the reverse comparison within the comparison matrix automatically. If a_{ij} is a value assigned within the matrix between cluster or element *i* to *j*, then a_{ji} is assigned a value of $1/a_{ij}$. When all pair wise comparisons are undertaken, the local priority vector can be derived as an estimate of the relative importance associated with the elements or clusters being compared by solving the following equation:

A: matrix of pairwise comparison

w: eigenvector

λ_{max}*: largest eigenvalue of A*

$$A \cdot w = \lambda_{max} \cdot w$$

For the approximation of *w* Saaty suggested several algorithms. For the purpose of this research SuperDecisions was used to compute the eigenvectors from the comparisons and to determine the CR which works as an indicator if a decision maker has a coherent understanding of the decision situation and is able to order according to dominance (Saaty, 2009). In theory a CR of 10% is described as acceptable (Saaty, 2009). Besides the evaluation by individual experts, group decision processes are also conceivable. A group decision process can be undertaken by a discussion and the agreement on one value for each pair wise comparison or by an ex-post combination of the expert evaluations. In such a situation, the geometric mean is the method of choice (Saaty, 2006; Saaty, 2008; Saaty & Vargas 2012). A possibility how to handle higher consistency factors within a real case group decision process with the help of the geometric mean is described in the paper.

3. The supermatrix

The concept of supermatrix is required to obtain global priorities in a system consisting of interdependencies. The supermatrix is a portioned matrix, consisting of matrix segments that are representing a relationship between two nodes of a network. The standard form of a supermatrix is shown below:

$$W_{kk}\text{: Matrix}$$

$$
W = \begin{array}{ccccccc}
 & & C_1 & \cdots & C_k & \cdots & C_n \\
 & & e_{11}\; e_{12} \;\cdots\; e_{1m_1} & \cdots & e_{k1}\; e_{k2} \;\cdots\; e_{km_k} & \cdots & e_{n1}\; e_{n2} \;\cdots\; e_{nm_k} \\
C_1 & \begin{matrix} e_{11} \\ e_{12} \\ \vdots \\ e_{1m_1} \end{matrix} & W_{11} & \cdots & W_{1k} & \cdots & W_{1n} \\
\vdots & \vdots & \vdots & & \vdots & & \vdots \\
C_k & \begin{matrix} e_{k1} \\ e_{k2} \\ \vdots \\ e_{km_k} \end{matrix} & W_{k1} & \cdots & W_{kk} & \cdots & W_{kn} \\
\vdots & \vdots & \vdots & & \vdots & & \vdots \\
C_n & \begin{matrix} e_{n1} \\ e_{n2} \\ \vdots \\ e_{nm_n} \end{matrix} & W_{n1} & \cdots & W_{nk} & \cdots & W_{nn}
\end{array}
$$

To make the supermatrix ‘columns stochastic’, so convergence can occur, it has to be considered, as there is usually interdependence among the clusters, that the columns mostly amount to more than one. To overcome this, the supermatrix has to be transformed with the goal that each column sums to unity. A common approach to do so is the determination of the relative importance of the clusters, using the column cluster as the controlling cluster. Based on this the relative importance can be used to be multiplied to each component within the cluster. As an outcome the blocks in each column of the supermatrix are weighted. This is called the weighted supermatrix.

In the next block the weighted supermatrix is raised to the power of $2k + 1$, so convergence occurs on the importance weights (k is an arbitrarily large number). As an output of the so called limit supermatrix, the long-term relative influences of the elements on each other can be determined. If each block of this supermatrix is furthermore normalized, the priorities of all elements of the matrix can be gained.

4. Alternative selection

In the classical proceeding of a multi criteria decision situation the decision makers would now be able, if the formed supermatrix covers the whole network, so no further calculations are required, to choose from the alternatives ordered in respect to their priority values. Besides a ‘simple’ selection of alternatives, how to use the outputs of an ANP furthermore is described in the paper.

SuperDecisions is the only available free ware until now to design an ANP (Hülle et al., 2013). It should be mentioned that if a network is not designed from scratch but built on a primary hierarchy, SuperDecisions and the underlying supermatrix tend to produce no valuable outputs (e.g., Saaty, 2004a). This aspect has been addressed in the case study by connecting all activities in each cluster with the goal node.

3 Fair Centralized Allocation of a Resource Reduction Level among Processes

Due to an increasingly competitive business environment, companies are forced to strive for advanced planning mechanisms to allocate their resources as optimally as possible. This allocation is often done centrally, and is ideally based on a performance analysis such as the Data Envelopment Analysis (DEA). However, some real life circumstances limit the usability of existing allocation approaches. First, if it is intended that the total resource level that should be allocated among processes is defined ex-ante, as is regularly the case within the strategic planning processes, a further decision-making problem that goes beyond DEA occurs. Second, the common assumption that external benchmarking figures are available to perform a DEA is often not fulfilled in business practice. To address these challenges, we developed a decision-support method allowing the allocation of an ex-ante defined resource level across the various processes of a single organization to ensure the achievement of overall organizational targets, without the requirement for collecting external benchmarking figures. We propose an allocation model formulated as a mixed-integer/linear program (MILP) that incorporates a social welfare function, allowing decision makers to consider fairness aspects. The practicability of the method is demonstrated in a real case setting by applying it to the indirect processes of a first-tier automotive supplier plant. The usability of the method is further underlined by comparing the real case results to alternative allocation strategies, as well as to the allocation strategy applied by the case organization so far. Assuming pre-defined allocation premises, our developed approach is beneficial in two ways: Either fewer activities are required to reach the total resource reduction level, or a lower overall strain level among the activities in respect of their improvement efforts can be achieved.

Keywords: Data Envelopment Analysis; Fairness; Mixed-Integer/Linear Programming, Centralized Decision Making

Pre-release: The research is accepted for presentation at the 13th International Conference on Data Envelopment Analysis 2015 (DEA2015) in Braunschweig, as well as the 23rd International Conference on Multiple Criteria Decision Making 2015 (MCDM2015) in Hamburg.

3.1 Introduction

Decisions on resource level reductions are commonly made by top management. For example, demanding market situations can make it necessary that all internal processes of an organization have to improve in the sense that they deliver the same level of output with fewer resources consumed. For the facilitation of the decision process by top management, advanced decision support methods are compulsory. The requirement of such methods is that they allow precise statements regarding where and the degree to which resource levels should be reduced to reach a pre-defined overall resource reduction level. Furthermore, fairness should be ensured among the decision alternatives regarding the efforts that each faces to reach the demanded improvements. The developed decision support method of this research fulfils these requirements.

In the literature, DEA has received distinct attention for the purpose of allocating resources centrally based on efficiency analyses since three groundbreaking papers in 2004 (Korhonen & Syrjänen, 2004; Lozano & Villa, 2004; Lozano et al., 2004). To measure the efficiency among decision making units (DMU), which can be processes of an organization, it is commonly assumed that benchmarking figures are available. However, the burdens of generating valuable (external) benchmarking figures that allow precise analysis are often very high and are probably not available at short notice. Therefore, it seems tempting to rely on internal organizational data for such an analysis (e.g. Seidenschwarz et al., 2009). Nonetheless, to the best of our knowledge, no research that discusses the possibilities and specific challenges of such an analysis in the context of centralized decision making has yet been published (see Literature Review). The potential heterogeneity in respect of the underlying different technologies of the processes needs to be considered when a DEA analysis among the internal processes of a single organization is performed. One approach that addresses heterogeneity among DMUs in the context of centralized resource allocation was introduced by Lozano (2014a), and will be used as a basis for the development of our method.

If the pre-defined resource reduction level is smaller than the maximum reduction level determined by DEA, the decision makers face the problem of determining resource reduction levels for each process. In such multiple-criteria decision situations additional allocation premises are required, which should further allow the consideration of decisions maker preferences (Korhonen & Syrjänen, 2004). Considering that the strain level of each process increases in tandem with its individual resource reduction level, we have developed an MILP for that purpose, allowing decision makers to control the level of fairness with regard to overall social welfare, based on a model introduced by Hooker and Williams (2012). We consider the strain level of a process to measure the required efforts of the processes to increase their efficiency by performing the same tasks with fewer resources consumed. The derived research question addressed in this research is consequently: *How to allocate a pre-defined resource reduction level among processes of a single organization considering their resource efficiency and overall allocation fairness?*

Fairness in the presented research means, based on the allocation premises of Hooker and Williams (2012), to aim for equity among the DMUs, following the maximin principle defined by Rawls (1971) – maximizing the welfare of the worst of – until it takes too many resources from others (Hooker & Williams, 2012), causing a switch to a utilitarian objective. The welfare of each activity is expressed by means of its individual strain level to reach cost reductions. To ensure the satisfaction of the fairness objective throughout the allocation process, a social welfare function is used, which was primarily introduced by Williams and Cookson (2000) and extended by Hooker and Williams (2012). The benefit of formulating a social welfare function for the purpose of allocating resource level reductions is that the function can be subject to different constraints and be maximized, allowing to always determine the most desirable equity/efficiency trade-off for the centralized decision maker. The developed decision-making method, relying only on internal information, is of particular interest for indirect processes (i.e. processes that are needed to keep the direct value generating process running), as the generation of reliable, external benchmarking figures for these processes is particularly difficult (Lee & Covell, 2008). Furthermore, as less improvement potential can currently be found in direct areas (Becker et al., 2007), a concentration of improvement activities in indirect areas takes place in business practice.

The structure of this research is as follows. We will first describe the requirements for allocating resources among the internal processes of an organization based on DEA in the literature review. With regard to the identified shortcomings of previous research, we develop our own approach. We will apply the developed method in a real case setting of a first-tier automotive supplier plant, analyzing indirect processes and evaluating the results in terms of alternative allocation proceedings. Potential limitations and a conclusion will be provided at the end.

3.2 Literature Review

DEA is a mathematical approach for the evaluation of the relative efficiency of DMUs (Banker et al., 1984). DEA is used for the measurement of the efficiency of a set of DMUs, in the sense that all DMUs transform the same type of resources (inputs) into the same type of products (outputs) using the same technology (Dyson et al., 2001). Accordingly, each DMU can consider all other DMUs as possible benchmarks to assess their relative efficiency. Since 2004, DEA has received specific attention in terms of managing resources centrally, striving for an overall optimization of the entire system. In the following (see Table 3.1), a complete forward citation review of Lozano and Villa (2004), Lozano et al. (2004) and Korhonen and Syrjänen (2004) is examined with regard to the fields to which the (further developed) centralized allocation methods are applied.[18]

[18] Extracted from the database ‘Scopus’; reference date 06.11.2014. In total, 110 publications have been identified, of which each cites at least one of the three papers; 55 publications have been identified as relevant for review. All studies address either the aspect of centralized resource allocation or target setting, two terms that should not be set equal (Beasley, 2003; Hadi-Vencheh et al., 2014), but which are not distinguished for the purpose of a comprehensive review in the following sections.

Field of application		Literature
Business units in the private sector		
	bank branches	Malekmohammadi et al., 2009; Mavi et al., 2010; Amirteimoori & Emrouznejad, 2012; Amirteimoori & Kordrostami, 2012; Liu & Tsai, 2012; Varmaz et al., 2013; Afsharian & Ahn, 2014; Hadi-Vencheh et al., 2014
	insurance branches	Hosseinzadeh Lotfi et al., 2010
	stores	Korhonen & Syrjänen, 2004; Gomes et al., 2008; Li & Cui, 2008; Vaz et al., 2010; Wu & An, 2012; Nasrabadi et al., 2012; Fang, 2013; Fang, 2015
	car dealers	Lozano, 2014b
	fast food restaurants	Du et al., 2010; Du & Liang, 2012; Lozano, 2014a
	manufacturing entities	Lozano et al., 2009; Malekmohammadi et al., 2010; Malekmohammadi et al., 2011; Hosseinzadeh Lotfi et al., 2012; Lozano, 2013; Malekmohammadi & Farid, 2014
Government owned organizations		
	airports	Yu et al., 2013
	ports	Lozano et al., 2011
	hospitals	Li & Cui, 2008
	gas companies	Amirteimoori & Kordrostami, 2011; Amirteimoori & Kordrostami, 2012; Hosseinzadeh Lotfi et al., 2013; Mirsalehy et al., 2014
Public institutions		
	fire departments	Fang & Zhang, 2008
	schools	Mar-Molinero et al., 2014
	university departments	Lozano, 2014b
	service units	Asmild et al., 2009
	research institutes	Mozaffari et al., 2014
	administrations	Doumpos & Cohen, 2014
	recycling organizations	Lozano et al., 2004
	forest management	Lozano, 2014a
Determination of emission regulations by regulating authorities		Hua et al., 2008; Hsiao et al., 2011; Li et al., 2013; Wang et al., 2013; Wu et al., 2013; Zhou et al., 2014
Control of city productivity levels		Lozano, 2014b
Numerical examples		Lozano & Villa, 2004; Villa et al., 2004; Lozano & Villa, 2005; Toloo & Joshaghani, 2009; Hassan et al., 2010; Lozano & Villa, 2010; Milioni et al., 2011; Guedes et al., 2012; Du et al., 2014

Table 3.1: Forward citation review of centralized resource allocation (own illustration)

All reviewed approaches have in common that DMUs are defined as more or less individual units and, within the case examples, the researcher could draw on external benchmark figures, time series analysis or data of parallel business units of multi-divisional organizations. However, the idea of defining the internal processes of a single organization as DMUs has not been raised by any research to the best of our knowledge.

It is commonly assumed that DMUs are homogenous. Nonetheless, when intending to apply DEA to detect inefficiencies among different processes of a single organization, potential sources of heterogeneity have to be considered. Heterogeneity can occur for different reasons. It can be caused by different technologies used by the DMUs (Tiedemann et al., 2011; Sala-Garrido et al., 2011; Medal-Bartual et al., 2012; Wu et al., 2012; Wang et al., 2013), differences in in- and outputs (Castelli et al., 2001; Saen et al., 2005; Cook et al., 2013), interdependencies between DMUs (Castelli et al., 2001), different sizes of DMUs (Sengupta, 2005; Samoilenko & Osei-Bryson, 2010), or even external factors (De Witte & Marques, 2010; Meza et al., 2011; Tao, 2013). Different approaches to addressing these sources of heterogeneity are described in the literature, and are reviewed in the following section.

One approach that has been identified several times in research is to cluster DMUs into homogenous groups and examine multiple DEAs. This can be done by the comparison of the generated efficiency values with the help of statistical tests (Lee et al., 2009), the usage of efficiency values of each analysis as a basis for decision trees (Samoilenko & Osei-Bryson, 2008), the usage of a correction respectively connection factor to create comprehensive DEA results based on single analysis (Meza et al., 2011; Gomes et al., 2012; Cook et al., 2013), or neural networks (Samoilenko & Osei-Bryson, 2010). Furthermore, the ex-post clustering based on the results of multiple and recursive DEAs has been suggested (Sharma & Yu, 2009). Moreover, in order to address the aspect of different technologies, metafrontier analyses have recently gained attention (Tiedemann et al., 2011; Sala-Garrido, 2011; Medal-Bartual et al., 2012; Wang et al., 2013). In addition, using multidivisional DEAs to consider the efficiency of DMUs simultaneously but independently in one model have been demonstrated (Wu et al., 2012). Furthermore, smoothing techniques have been examined to reduce random variations causing heterogeneity, and are based on statistical tests and regression analysis (Sengupta, 2005). In order to ensure homogenous ex-ante data, the selection of only relevant benchmark partners has also been suggested (Adler et al., 2013). To address interdependencies between sub DMUs, the concept of network DEA has been introduced (e.g., Castelli et al., 2001). Finally, if in- or output values are missing, AHP has been applied to generate such missing values (Saen et al., 2005).

However, and as far as we can tell, the aspect of a potential lack of homogeneity in the context of centralized decision making has only been addressed in two studies (Barnum & Gleason, 2010; Lozano, 2014a). While Barnum and Gleason (2010) assumed that the decision maker can still draw on parallel and therefore homogenous DMUs, Lozano's (2014a) approach reconsiders this limitation. To address the aspect of missing homogeneity caused by different technologies used by the DMUs, he suggested dividing DMUs into homogenous groups characterized by the same type of technology. A DEA is then examined separately for each of these technology clusters. Lozano's (2014a) approach has been applied in the context of fast food restaurants and forest management regulations.

There are some restrictions to applying Loanzo's (2014a) approach for the allocation of resource level reductions among the processes of a single organization. While these restrictions can be addressed fairly easy by adapting the model's constraints (see method development), the approach has its limitations if an ex-ante target setting of a total resource level is intended as a further multiple criteria problem emerges, which is addressed in the following section.

3.3 Methodology

The methodology addresses the research question, and is based on two mains steps including data collection and the definition of allocation premises (see Figure 3.1).

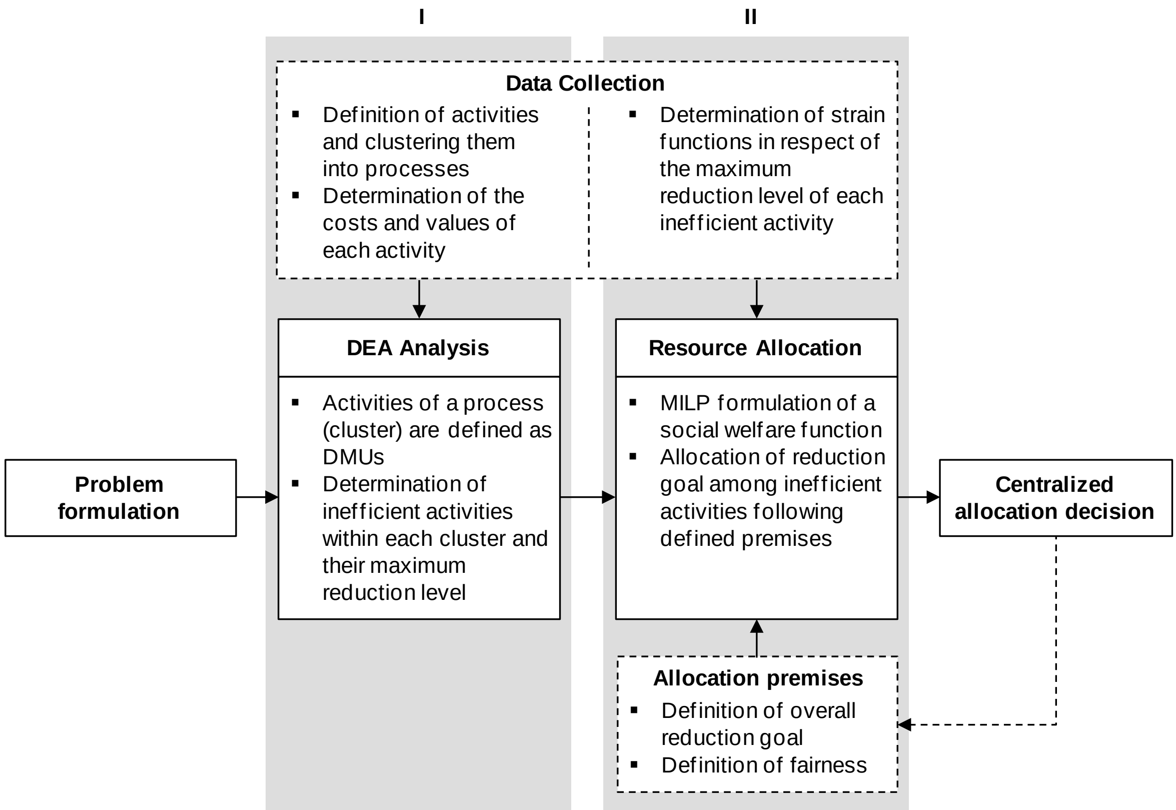


Figure 3.1: Method development (own illustration)

Step I

The activities (a) of an organization are identified and clustered into homogenous processes (p).[19] Within a process, activities can be considered homogenous and comparable with a DEA using the same technology. Each activity (a) has the same kind of inputs (I) and outputs (O) given by the amounts x_{ia} (inputs consumed) respectively y_{oa} (outputs generated). The processes can be heterogeneous with each other. A variable returns to scale DEA model based on Lozano (2014a) is proposed in the following to identify the minimum input level ($\hat{x}_{ia}$) needed for each activity whilst still being able to perform the same tasks. More precisely, the same output needs to be producible as formulated through the constraint (3), added to the approach of Lozano (2014a) (e.g., Barnum et al., 2011).

The maximum cost reduction of each activity (R_a) (given by $R_a = c_{ia}\ (x_{ia} - \hat{x}_{ia})$) is determined by the difference between the current input level (x_{ia}) and the minimum level calculated by the DEA. In the resource allocation in step II, only the inefficient activities (i.e. $x_{ia} > \hat{x}_{ia}$) are considered. This is done because the acceptance of the derived targets would otherwise be low in real case examples, and the efficient activities would not work in respect of their in- and output possibilities set as a benchmark for the inefficient activities, as claimed by Asmild et al. (2009). It is noteworthy that, in this model, we do not consider the option of closing down activities as suggested by Lozano (2014a), as it is not feasible in the context of continuous improvement management, which aims for an improvement of the existing processes, not a reorganization of them.

Sets

A_p	set of activities a belonging to process p
I	set of inputs indexed by i
O	set of outputs indexed by o
P	set of processes indexed by p

Parameters

c_{ia}	unit costs of input i for activity a
x_{ia}	amount of input i consumed by activity a
y_{oa}	amount of output o generated by activity a

[19] All notations and symbols used in this chapter can be found in an overview at the end of this thesis.

Decision variables

λ_{ja}	multiplier variable on activity *j* corresponding to activity *a*
$\hat{x}_{ia}$	minimum amount of input *i* to be consumed by activity *a*

Objective function

$$min \sum_{p \in P} \sum_{a \in A_p} \sum_{i \in I} c_{ia}\, \hat{x}_{ia} \tag{1}$$

Constraints

$$\sum_{j \in A_p} \lambda_{ja} x_{ij} \leq \hat{x}_{ia} \qquad \forall\, i \in I \;\; \forall\, p \in P \;\; \forall\, a \in A_p \tag{2}$$

$$\sum_{j \in A_p} \lambda_{ja} y_{oj} = y_{oa} \qquad \forall\, o \in O \;\; \forall\, p \in P \;\; \forall\, a \in A_p \tag{3}$$

$$\sum_{j \in A_p} \lambda_{ja} = 1 \qquad \forall\, p \in P \;\; \forall\, a \in A_p \tag{4}$$

$$\lambda_{ja} \geq 0 \qquad \forall\, p \in P \;\; \forall\, j \in A_p \;\; \forall\, a \in A_p \tag{5}$$

$$\hat{x}_{ia} \geq 0 \qquad \forall\, p \in P \;\; \forall\, j \in A_p \;\; \forall\, a \in A_p \tag{6}$$

Step II

The DEA has highlighted the inefficient activities. The second step is to define which and how much each activity needs to improve given the reduction goal *G* defined by the centralized decision maker. By improvement, we mean to reduce the costs whilst producing the same value. If a constraint aiming for the allocation of the desired reduction goal were to be added to the model in step I, but if *G* were to be smaller than the determined maximum overall reduction level ($G < \sum_{a \in A} R_a$), DEA would randomly select any solution among the infinite amount of possible, optimal solutions. This could lead to extreme allocation scenarios in which, for example, some activities could receive very demanding reduction targets, while others none. Consequently, further allocation objectives are required to ensure a specific and precise allocation proceeding.

Therefore we incorporated fairness, an objective that has received recent attention in literature (e.g., Ogryczak et al., 2006; Bertsimas et al., 2012), in our method development. To allow the consideration of fairness in respect of the strain of each activity to reach improvements, we based our approach on an allocation model developed by Hooker and Williams (2012). If alternative objectives should be considered to ensure a precise allocation proceeding, for example the ability of each DMU to change its input-output mix, alternative multiple criteria methods might be of interest as well (e.g., Korhonen & Syrjänen, 2004). Yet, the approach of Hooker and Williams (2012) is so far the only approach available that allows considering individual strain respectively utility levels of each DMU to the best of our knowledge.

As said before, the approach of Hooker and Williams (2012) is based on a social welfare function which is maximized in a MILP formulation. The two allocation principles integrated in this model are a maximin principle and, in extreme situations, a utilitarian objective. This allows the consideration of equity and efficiency in the decision process. In order to be in line with Hooker and Williams (2012), we defined the utility level (u_a) of each activity in respect of its strain level (s_a) as: $u_a = 1 - s_a$ where $s_a \in [0,1]$. The switch between the maximin principle to utilitarian objectives occurs when the difference between the utilities is higher than Δ: $u_a - u_{min} \geq \Delta$ with u_{min} being the lowest utility among all utilities. The threshold parameter Δ has to be defined by the decision maker within the allocation process, and is measured in the same units as the utilities of the decision elements. If Δ is chosen once, it ensures that the same policy is applied in any allocation situation by maximizing the social welfare function. In the following, the 'many persons problem' discussed by Hooker and Williams (2012) is used as a basis.

As the aim of this research is to facilitate the allocation of resource level reductions among activities, we will focus on the strain on each activity in reaching the required resource reduction levels. The necessary strain functions of the activities, required to design the *n*-person model, have to indicate how the strain level of the activities changes with an increasing reduction level, and indicate their specific strain in respect of the intended cost reductions (r_a; $0 \leq r_a \leq R_a$). The strain level maximum at $s_a = 1$ is reached when $r_a = R_a$. How strain functions can be determined with regard to R_a is described in the subsequent segment. As a linear form of the functions is required, and assuming that the strain shapes are probably not mandatorily steady, a set of intervals (D) for the validity of piece-wise linearized functions is defined. The interval in which r_a is allocated is determined by the lower (lb_{ad}) and upper bounds (ub_{ad}) of the intervals and φ_{ad}. To border the linearized utility functions in each interval in respect of r_a, further auxiliary decision variables, k_{ad}^- and k_{ad}^+ are introduced. Furthermore, we rely on additional decision variables, originally defined by Hooker and Williams (2012), which are required to perform the resource allocation: v_a and δ_a.

The following optimization model consequently calculates the allocated resource reduction (r_a) among inefficient activities in order to achieve the overall reduction goal (G). The decision maker can decide, in order to ensure fairness, to place more focus on either equity or utility among the activities in the allocation process through the choice of Δ. In other words, the Δ determines how many inefficient activities have to contribute in order to reach the overall resource level, and to what extent. For purposes of illustration, an exemplary illustration of the linearized utility and strain functions required within the developed optimization model is shown in Figure 3.2.

Parameters

b_{ad}	y-intercept of the utility function of activity *a* in interval *d*
D	number of intervals *d*
Δ	threshold for switching from efficiency approach to equity approach
G	reduction goal
lb_{ad}	lower bound of the d^{th} interval of activity *a*
M	large number
m_{ad}	slope of the utility function of activity a in interval *d*
n	number of activities
R_a	maximum possible cost reduction of activity *a*
ub_{ad}	upper bound of the d^{th} interval of activity *a*

Decision variables

r_a	cost reduction for activity *a*
u_a	utility level of activity *a*
w	lowest utility level amongst all activities
z	overall utility contribution amongst all activities

Auxiliary decision variables

$$k^-_{ad} = \begin{cases} 1 \text{ if } r_a \geq lb_{ad} \\ 0 \quad \text{otherwise} \end{cases}$$

$$k^+_{ad} = \begin{cases} 1 \text{ if } r_a \leq ub_{ad} \\ 0 \quad \text{otherwise} \end{cases}$$

$$\varphi_{ad} = \begin{cases} 1 \text{ if } lb_{ad} \leq r_a \leq ub_{ad} \\ 0 \quad \text{otherwise} \end{cases}$$

δ_a	binary variable indicating if activity *a* is making a utilitarian ($\delta_a = 1$) or a rawlsian ($\delta_a = 0$) contribution in the objective function
v_a	auxilliary decision variable to specify the objective function contribution of activity *a*

Objective function

$$max\ z \tag{7}$$

Constraints

$$z \leq (n-1)\,\Delta + \sum_{p \in P} \sum_{a \in A_p} v_a \tag{8}$$

$$u_a - \Delta \leq v_a \leq u_a - \Delta\,\delta_a \qquad \forall\, p \in P \;\; \forall\, a \in A_p \tag{9}$$

$$w \leq v_a \leq w + (M - \Delta)\,\delta_a \qquad \forall\, p \in P \;\; \forall\, a \in A_p \tag{10}$$

$$u_a - m_{ad}\, r_a \leq b_{ad} + M\left(1 - \varphi_{ad}\right) \qquad \forall\, p \in P \;\; \forall\, a \in A_p \;\; d = 1, \ldots, D \tag{11}$$

$$lb_{ad}\, k^-_{ad} \leq r_a \qquad \forall\, p \in P \;\; \forall\, a \in A_p \;\; d = 1, \ldots, D \tag{12}$$

$$r_a \leq ub_{ad}\, k^+_{ad} + \left(1 - k^+_{ad}\right) M \qquad \forall\, p \in P \;\; \forall\, a \in A_p \;\; d = 1, \ldots, D \tag{13}$$

$$k^-_{ad} + k^+_{ad} = 1 + \varphi_{ad} \qquad \forall\, p \in P \;\; \forall\, a \in A_p \;\; d = 1, \ldots, D \tag{14}$$

$$\sum_{d=1}^{D} \varphi_{ad} = 1 \qquad \forall\, p \in P \;\; \forall\, a \in A_p \tag{15}$$

$$\sum_{p \in P} \sum_{a \in A_p} r_a \geq G \tag{16}$$

$$0 \leq r_a \leq R_a \qquad \forall\, p \in P \;\; \forall\, a \in A_p \tag{17}$$

$$u_a \geq 0 \qquad \forall\, p \in P \;\; \forall\, a \in A_p \tag{18}$$

$$\delta_a \in \{0,1\} \qquad \forall\, p \in P \;\; \forall\, a \in A_p \tag{19}$$

The objective function (7) is maximized, aiming for a maximization of the social welfare. Constraints (8)–(10) ensure that the premises underlying the objective function (following a maximin principle and, in extreme situations, a utilitarian objective) are ensured. δ_a is 0 and v_a is u_{min} if $u_a - u_{min} < \Delta$ and 1 respectively $u_a - \Delta$ otherwise. Constraints (11)–(15) connect the utility via the strain of activities a and the corresponding reduction target r_a, respectively. This is done via a linearization of the utility with regard to the strain functions. Constraint (16) ensures that the overall target G is met, while constraint (17) ensures that r_a does not exceed R_a. Finally, constraints (18) and (19) define the domain of the remaining decision variables.

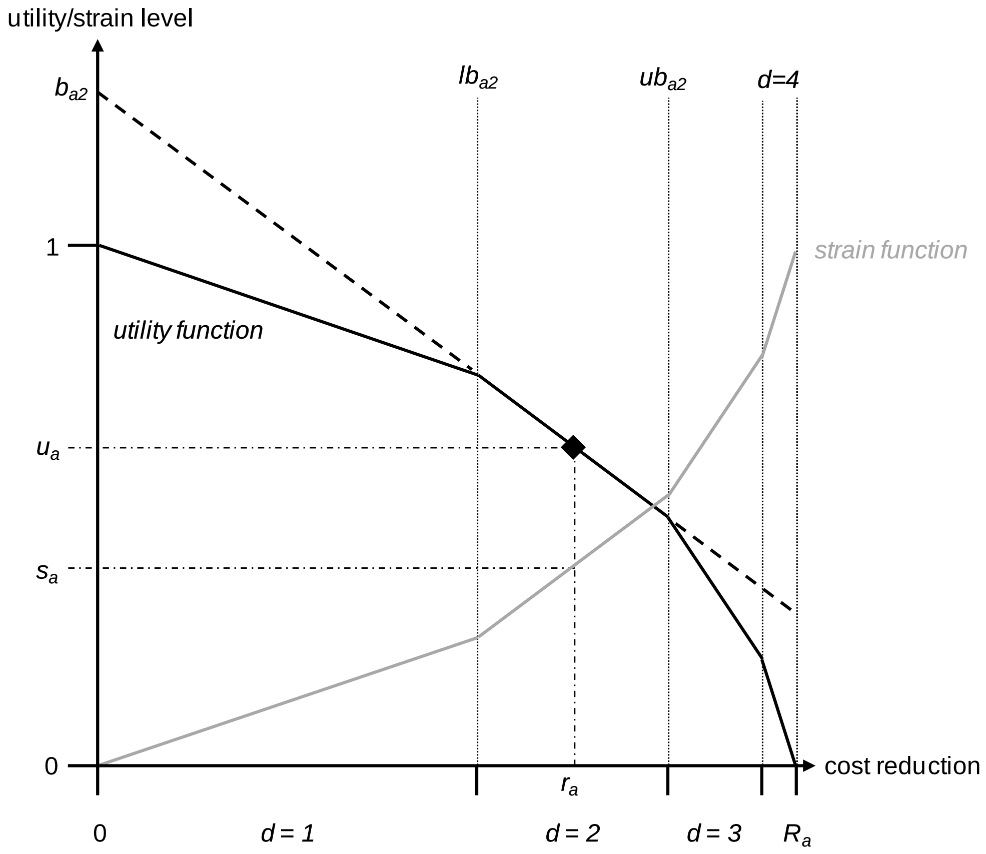


Figure 3.2: Exemplary illustration of a linearized utility and a strain function (own illustration)

To facilitate the implementation of the developed approach in real case situations, we describe how best to collect the necessary data in the following section.

Data collection

A comprehensive preceding of how to generate required input values for the DEA, respective costs, as well as outputs assumed as values, is described in paper 1 (Chapter 2 in this thesis) – these data will be used in our case study. The central idea is to define processes and subordinated activities as alternatives within an Analytic Network Process (ANP), allowing the determination of the impact of each activity on superior goals and further processes within an organization (internal customer-supplier relationship). Furthermore, activity-based costing (ABC), which has demonstrated its usability to provide appropriate cost information in several applications, is used to allocate the costs. In addition to this specific, yet promising proceeding, there are plenty of other conceivable possibilities to determine the required information. For example, one might consider time series ABC (Kaplan & Anderson, 2004; Hoozée & Bruggeman, 2010) for cost data, or key performance indicator trees (Donko, 2012) to measure process values. Furthermore, the idea of internal transfer prices can also be considered as a potential basis (Johnson, 1988).

One essential element of Hooker and Williams' (2012) approach is the definition of a utility function. To determine utility functions, several approaches are conceivable (Farquhar, 1984), although there is still no gold standard for doing so (Heldmann et al., 2009). In our case study, the extraction of the utility function with the help of a strain function by expert evaluations and piece-wise linearization, roughly based on a certainty equivalence approach described by Goodwin and Wright (2004), has demonstrated its usability. In future application contexts, some might consider SMART(ER) (Edwards & Barron, 1994) or UTA (Jacquet-Lagreze & Siskos, 1982) to be useful. These are two commonly discussed approaches in the literature to determine utility functions.

3.4 Case Study

To demonstrate the usability of the developed method, we applied it in a real case setting. We will describe how the data have been collected to perform the analysis. We will furthermore interpret the results in depth, and compare them to the results of alternative allocation proceedings.

Organizational context

The case study organization is a first-tier automotive supplier plant that is confronted by demanding cost pressures. Top management asserted that cost reductions across their indirect processes were crucial in order to stay competitive. In the following, the same process data are used as in paper 1 (Chapter 2 in this thesis).

Step I

First, the direct core processes of the plant and all indirect activities a (DMUs for DEA) that increase the internal, and indirectly the external customer value, were identified. The activities range across logistics, maintenance, and quality management functions. The activities were clustered into homogenous processes p (clusters for DEA) and the interdependencies between them were identified.

The 83 identified activities were then analyzed using ABC to determine their costs ($c_{ia}x_{ia}$ – inputs in DEA). The ANP, which takes into account interdependencies, was applied to determine their values in ensuring the direct processes of the organization's running (y_{oa} – output in DEA). The values of the activities were assessed according to the criteria of quality and delivery in a group decision process (see Appendix 3.7.2, Table 3.6).

Given these data, the maximum cost reduction of each activity was calculated. Both optimization models were implemented and solved using CPLEX 12.6 on a Laptop running Windows 8 with an Intel i7-4500U processor with 8GB Ram. As all instances could be solved within a few minutes, we do not address the issue of computational time. 31 of 83 activities were found inefficient. Their total reduction potential is 15.94 million EUR, which is 28% of the total costs (56.56 million EUR) incurred by all activities in one fiscal business year (see Appendix 3.7.2, Table 3.7).

With regard to the heterogeneity of the examined processes, it should be pointed out that they all serve the same organizational internal customer (direct production process), allowing the evaluation of all activities in one ANP model using overall valid evaluation criteria. Furthermore, as the activities depend on each other, having an impact on the respective priority value of each activity in the ANP analysis, a non-centralized analysis of the allocation of the overall target *G* would probably lead to only a partially optimal solution.

Step II

A reduction target *G* is determined by the central decision maker. In the case study research, we examined possible total reductions from 1 to 15 million EUR, with 1 million EUR interval steps. Each cost reduction level was examined in respect of Δ ranging from 0 to 1 in 0.01 steps. In total we identified 1.515 possible allocation scenarios (101 different Δ, 15 cost reduction levels).

<u>Choice of utility function</u>

An expert focus group, including two senior accounting managers and one process expert, was held in order to construct the strain functions of the activities. For that purpose one representative activity of each of the eight clusters was chosen for the discussion. As already described, a strain function is defined on a scale of 1 to 0, where 1 means the highest strain and 0 means no strain.

In Figure 3.3 the possible shapes of the strain curves discussed by the experts can be found as well as a brief explanation why they appealed as reasonable to them. Within the discussion it was decided by the experts that the function type 2 represents the most appropriate shape for all activities and should therefore be considered for the further data analysis. This is in line with the assumption that the utility function of a risk averse behavior (which we assume in such a decision situation) is best described by a monotonic increasing concave function (Murthy & Sarkar, 1998). Since in our setting the strain is the inverse of the utility and therefore rather a loss than a gain, as described on the y-axis, the choice of a convex strain function is supported (see discussion for criticism).

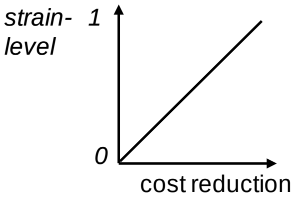
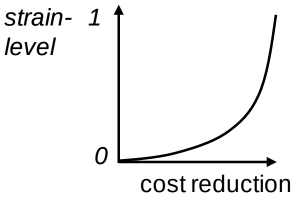
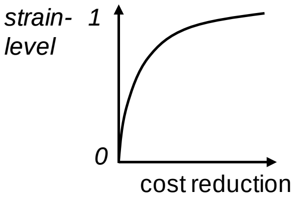
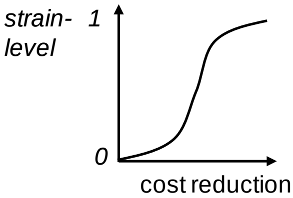
	Strain function	Explanation
1.		*"As the activity is driven by repetitive subtasks, the strain of reduction should increase linearly with the increase of the intended cost reductions."*
2.		*"The first improvements should be achieved fairly easy, but approaching the maximum reduction, it will become very difficult."*
3.		*"Any improvement will lead to major interruptions. If the first improvements are realized, further improvements should not cause that much more strain."*
4.		*"The first improvements should be achieved fairly easy, but at some point major difficulties will emerge, that are hard to realize. If these difficulties are overcome, further improvements should not cause that much more strain."*

Figure 3.3: Shapes of the strain curves and explanations (own illustration)

The experts were then asked to determine in a certainty equivalence approach and using a mid-value splitting technique, what represents half the difficulty of reaching the maximum reduction level, respectively one quarter for the activities (see Appendix 3.7.1 for how the request was designed). The function shape extracted from this approach is shown in Table 3.2 in the intervals *d* according to R_a, revealing the maximum cost reduction determined by DEA (x-intercept).

d	m_{ad}	b_{ad}
1	$-\frac{0.25}{0{,}56\,R_a}$	1
2	$-\frac{0.25}{0{,}25\,R_a}$	1.3
3	$-\frac{0.25}{0{,}14\,R_a}$	1.94
4	$-\frac{0.25}{0{,}05\,R_a}$	5.33

Table 3.2: Linearized concave utility function of type 2 (own illustration)

Choice of Δ

The central decision maker needs to determine Δ. Hooker and Williams (2012) do not discuss how this should be done in general, as allocation strategy that should be followed is for the decision maker to decide. However, in respect of the case setting a range of Δ and some turning points can be detected, which are probably of high interest for the decision maker. The range from 0 to Δ, in which at least for one activity δ_a=1 is valid, making a utilitarian contribution to the objective function, is listed in Table 3.3. For this purpose, we define Δ_{rawl} to be the threshold at which any $\Delta \in [\Delta_{rawl},1]$ will lead to an allocation scenario in which all activities make a maximin contribution.

	Reduction goals *G* in million EUR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Δ_{rawl}	0.04	0.06	0.09	0.10	0.14	0.17	0.20	0.23	0.25	0.31	0.37	0.43	0.47	0.59	0.70

Table 3.3: Δ_{rawl} for various reduction goals *G* (own illustration)

Furthermore, an interesting turning point could be identified, in which the number of activities that have to contribute in order to reach the overall reduction goal ($r_a > 0$) increases abruptly with larger Δ, and the number of those with δ_a=1 (meaning more activities contributing to the social welfare function by the maximin principle) drops sharply at the same time. For a reduction level *G* of 10 million EUR, for example, this turning point lies between a Δ of 0.23 and 0.24 (see Figure 3.4). Furthermore, the cumulated total strain level of all activities experiences the sharpest increase at this point (see Figure 3.5).

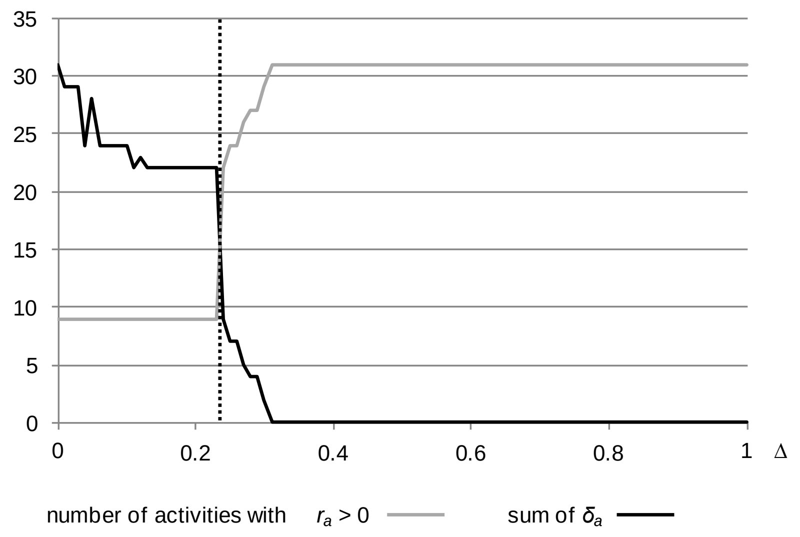


Figure 3.4: Turning point reduction level 10 million EUR (own illustration)

With regard to a possible demand to reach other (most likely higher) reduction goals over time, and the fact that Δ is probably chosen only once to ensure consistent policymaking, this turning point is of additional interest. If, for example, a reduction level of 11 million EUR is intended, this point also indicates when a switch from 10 to 11 million EUR would allow the decision maker to tare a level, so that the total strain level, as well as the number of activities that need to contribute in order to reach the total reduction goal, would be the same (see Figure 3.5).

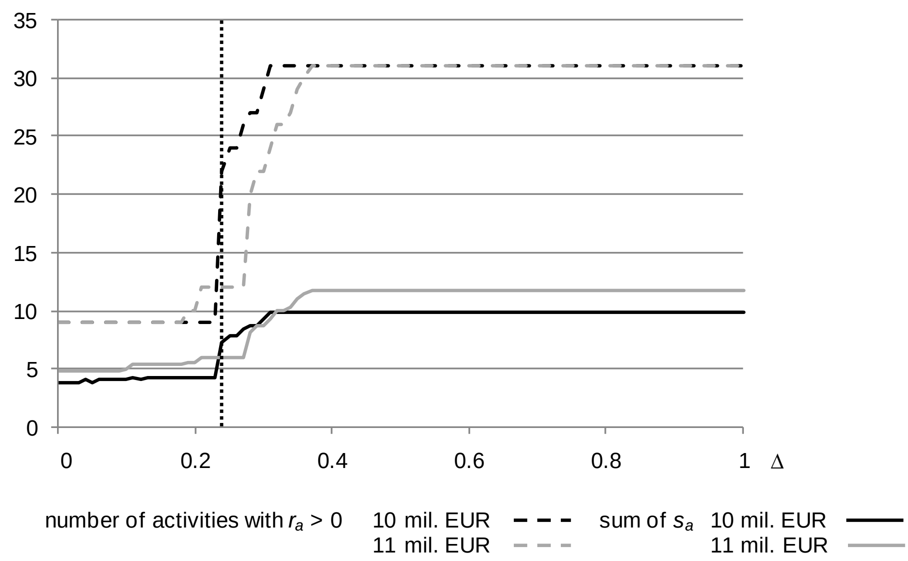


Figure 3.5: Turning point reduction level 10 million EUR in comparison to a reduction level of 11 million EUR (own illustration)

However, it would not be possible to prevent at least one activity from experiencing a sharp increase in strain as *w* indicates, shown in Table 3.4 (meaning that the utility level of the worst off will drop, indicating at the same time that its corresponding strain level increases; see Figure 3.7 and 3.8 in Appendix 3.7.2 for a detailed comparison of the change in distribution of the individual strain levels among the activities).

	Δ	
	0.23	0.24
w for reduction of 10 million EUR	0.524	0.666
w for reduction of 11 million EUR	0.502	0.502

Table 3.4: Comparison of *w* at turning point (own illustration)

Even though no general recommendation could be derived regarding how to choose Δ, the analysis shows that at least an interesting range could be identified, which is probably worthwhile for the decision makers to consider.

Comparison to alternative resource allocations

The advantage of the developed approach becomes obvious when the allocation results are compared with alternative methods (analyzing a total reduction goal of 10 million EUR). Considering the absence of reliable information about the potential for the improvement of activities by management in practice, some might call for the consideration of the Pareto-principle (e.g., Grosfeld-Nir et al., 2007) to allocate the required reductions among activities bearing the largest costs. The Pareto-principle has actually been applied on a regular basis at the case study organization in several resource allocation situations, and has also been applied in previous budgeting processes for the examined indirect processes. In this research, we impose uniformly distributed cost reductions among the activities that contribute 80% of the total costs (37 of 83 activities) corresponding to their share of the total desired reduction level. In addition, the Target Setting for Indirect Processes (TSIP) method (developed in Chapter 2) can be considered as a valid alternative to decide on the activities that require cost reductions and is currently applied by the case organization. The method, based on an adapted value control chart, also suggests imposing the reductions on 37 activities (not completely the same as in the Pareto-principle). The resulting strain levels for both approaches (TSIP and Pareto) were determined with the assistance of the above-defined, convex-shaped strain function (type 2). For those activities that should receive targets within the Pareto and TSIP proceeding, but which are performing their tasks efficiently according to the DEA (R_a=0), we considered the same function shape, assuming that their maximum reduction is equal to their total costs. By so doing, those activities are probably included in the analysis with strain values that are too low. In Table 3.5, the results of these two proceedings in comparison to our developed method are reflected.

	Pareto	TSIP	New approach		
			Δ		
			0	0.23	>0.31
sum of strain level ($\sum s_a$)	7.11	6.01	3.81	4.29	9.85
highest strain	1.00	1.00	0.75	0.48	0.32
second highest strain	1.00	0.57	0.75	0.48	0.32
third highest strain	1.00	0.52	0.56	0.48	0.32
number of required reductions	37	37	9	9	31

Table 3.5: Comparison of the results of different allocation proceedings (own illustration)

Within the Pareto-principle, it is remarkable that the highest strains are all 1 (non-efficient activities according to DEA obtained targets larger or equal to R_a). Even though the sum of the strain values of all activities is not significantly high (keeping in mind the probability of strain value that are too low), it is doubtful that the imposed reductions can be reached. In comparison, the TSIP approach reaches a lower overall strain level, and the strains of the activities are, apart from one exception, lower than 0.6. One reason is that the TSIP approach is based on an efficiency analysis and considers the ‘potential for improvement’ of each activity, determined by an ANP analysis, within its allocation process (implicitly representing an alternative formulation of the production function of each process). Therefore, the probability of reaching the imposed reductions can be considered to be much higher. With regard to our developed method, it is remarkable that, if a low Δ is chosen, even lower strain values can be reached with considerably smaller numbers of activities that need to contribute. However, these activities experience relatively high strain levels. Summarizing our developed approach is beneficial for two reasons. First, all allocated resource level reductions lie within the production possibility set of the respective activities; second, the satisfaction of a pre-defined fairness policy among the activities by the centralized decision maker is ensured.

3.5 Discussion

The method is of an innovative character, as it allows an allocation procedure of resources among internal and imperfectly homogeneous processes, considering efficiency and fairness aspects without the need for gathering external data. However, the associated efforts cannot be denied. Specifically, the determination of the process and activity values and their respective strain functions demand some effort. This was also the case in the examined real case study. Even though it was intended to keep the efforts at a reasonable level to determine the strain functions, it appeared that different experts evaluated the activities differently, making additional, in-depth discussions and simplifications necessary. Along with these simplifications a potential loss in accuracy and increase in subjectivity cannot be denied. In future research alternative strain function extractions (as described in Chapter 3.3) might therefore be of interest.

Considering the usage of DEA for efficiency analysis, one general aspect of DEA has to be reflected critically as well: the number of activities under each process might not be sufficient in all case settings (rule of thumb: the number of DMUs should be at least three times as high as the sum of all input and output factors [Paradi & Zhu, 2013]). Even though this could just be a matter of how to design the process structure appropriately in real case contexts, this aspect should not go unmentioned. Furthermore it needs to be considered that, if an ANP is intended to determine the process values, the number of alternatives should not exceed a critical large number at the same time. Therefore in the case study design adaptations for the ANP analysis were necessary in cooperation with the case organization.

In respect of the specific application of the TSIP idea presented in Chapter 2 to determine the activity values, it has to be mentioned that the derived priority values from ANP are probably only valid in the context of continuous improvement management. In the case of radical cost reductions, the process structure might become obsolete, and a reexamination of the evaluations would be necessary (which would probably be necessary for some activities of the cooperating organization if the suggested reduction targets discussed in the case study are to be realized in business practice).

Even though the suggested method allows a resource allocation process that considers fairness aspects, it is not likely that all managers and associates involved in the processes and activities (especially those that contribute to reaching the overall reduction goal) will perceive the proceedings as fair. In particular, the determination of Δ by the central decision maker, most likely from top management or the management accounting department, can be considered by those affected heavily as being arbitrary. No general applicable recommendation can be formulated on how to choose Δ. Nevertheless, interesting ranges and turning points could be identified. However, if an exact determination of the policy-determining variable is desired, alternative proceedings to ensure precise allocation objectives are conceivable (Bertsimas et al., 2012), which in turn may however not address the consideration of the individual strain of each activity in order to reach improvements.

3.6 Conclusion

The allocation of resources by a central decision maker is a highly challenging task. The literature has not given detailed insight into how to do so if resources are to be allocated among processes of a single organization, and in the absence of (external) benchmarking figures. The core idea of our method is to define processes and their corresponding costs as inputs, and their value as output within a DEA. The possible low levels of homogeneity among the processes are addressed. Based on these results, resources are allocated by means of an optimization model, incorporating a social welfare function that enables the centralized decision maker to determine whether the focus should be on equity or utility. Furthermore, the method allows the decision maker to decide whether the aim is to allocate required reductions among more or fewer activities. The advantage of the developed approach became obvious when applied in a real case setting, and when compared to alternative allocation methods. It allows for the allocation of resource reductions among significantly fewer processes, while still generating low strain levels and ensuring fairness. With regard to the unique possibilities of the developed method and the demand of managers for advanced allocation methods, along with an increase in the dissemination of comprehensive process management approaches, we are hopeful that the research insights will gain wider attention in academia and in practice.

3.7 Appendix

3.7.1 Strain Function Extraction

The certainty equivalence approach that was used to extract the strain function was designed as the follows: the process experts of the case organization were requested to evaluate piece-wise what represents half of the difficulty level and that which represents one and three quarters, respectively, in order to reach the total reduction level of activity 3.5 ($x_{i3.5}$ = 492.437; $R_{3.5}$ = 338.480). The request was designed using spreadsheet software. Based on the evaluations, the piece-wise linearized utility function was derived in respect of R_a. and by inverting s_a The proceeding is exemplarily shown below, indicating the request for two intervals (one quarter and half the strain with regard to the maximum reduction level).

					Yes	
Do you perceive the reduction of	169.240	as half as difficult as as the reduction of	338.480	?	No, less difficult.	x
					No, more difficult.	
					Yes	
Do you perceive the reduction of	253.860	as half as difficult as as the reduction of	338.480	?	No, less difficult.	x
					No, more difficult.	
					Yes	
Do you perceive the reduction of	296.170	as half as difficult as as the reduction of	338.480	?	No, less difficult.	
					No, more difficult.	x
					Yes	x
Do you perceive the reduction of	275.015	as half as difficult as as the reduction of	338.480	?	No, less difficult.	
					No, more difficult.	
					Yes	
Do you perceive the reduction of	137.508	as half as difficult as as the reduction of	275.015	?	No, less difficult.	x
					No, more difficult.	
					Yes	
Do you perceive the reduction of	206.261	as half as difficult as as the reduction of	275.015	?	No, less difficult.	
					No, more difficult.	x
					Yes	
Do you perceive the reduction of	171.884	as half as difficult as as the reduction of	275.015	?	No, less difficult.	x
					No, more difficult.	
					Yes	x
Do you perceive the reduction of	189.073	as half as difficult as as the reduction of	275.015	?	No, less difficult.	
					No, more difficult.	

Figure 3.6: Exemplary certainty equivalence approach (own illustration)

3.7.2 Case Study Data Analysis

a - activity-	x_{ia} [EUR]	y_{oa} - quality-	y_{oa} - delivery-
1.1	8.214	0.001	0.003
1.2	65.712	0.011	0.004
1.3	123.210	0.005	0.003
1.4	41.070	0.002	0.003
1.5	8.214	0.001	0.002
1.6	748.198	0.008	0.005
1.7	24.642	0.003	0.004
1.8	82.140	0.003	0.003
1.9	8.214	0.001	0.002
1.10	1.235.693	0.010	0.121
1.11	1.000.807	0.010	0.075
1.12	1.820.540	0.010	0.043
1.13	297.875	0.010	0.034
2.1	61.099	0.001	0.002
2.2	236.314	0.001	0.002
2.3	365.657	0.002	0.002
2.4	303.555	0.002	0.002
2.5	237.703	0.003	0.002
2.6	425.447	0.015	0.002
2.7	651.869	0.015	0.002
2.8	280.732	0.012	0.011
3.1	195.573	0.008	0.001
3.2	905.638	0.008	0.002
3.3	452.819	0.061	0.008
3.4	204.014	0.004	0.000
3.5	492.437	0.010	0.005
3.6	2.083.747	0.010	0.010
3.7	392.579	0.009	0.017
3.8	121.971	0.011	0.007
3.9	242.627	0.013	0.002
3.10	290.279	0.010	0.002
4.1	1.513.443	0.017	0.021
4.2	62.696	0.008	0.004
4.3	160.240	0.010	0.015
4.4	312.132	0.006	0.003
4.5	427.128	0.007	0.006
4.6	6.911.206	0.091	0.026
4.7	2.226.686	0.034	0.058
4.8	2.123.634	0.008	0.024
4.9	1.087.685	0.033	0.009
4.10	1.339.668	0.033	0.033
4.11	664.902	0.006	0.057
5.1	148.302	0.004	0.001
5.2	323.483	0.009	0.007
5.3	328.560	0.003	0.002
5.4	82.140	0.003	0.002
5.5	287.490	0.006	0.005
5.6	32.856	0.004	0.003
5.7	410.700	0.042	0.005
5.8	328.560	0.096	0.027
5.9	82.140	0.005	0.003
5.10	82.140	0.009	0.003
5.11	134.399	0.059	0.019
5.12	263.236	0.013	0.018
5.13	228.560	0.028	0.018
6.1	545.443	0.002	0.006
6.2	2.051.585	0.002	0.010
6.3	444.012	0.001	0.001
6.4	1.442.738	0.000	0.001
6.5	665.093	0.001	0.004
6.6	2.660.371	0.001	0.008
6.7	590.783	0.000	0.000
6.8	368.879	0.000	0.000
6.9	484.082	0.000	0.001
6.10	418.576	0.000	0.001
6.11	3.661.751	0.003	0.015
6.12	406.533	0.003	0.015
7.1	998.168	0.006	0.014
7.2	845.905	0.006	0.014
7.3	284.777	0.005	0.013
7.4	274.834	0.004	0.012
7.5	154.141	0.002	0.008
7.6	1.518.811	0.004	0.012
7.7	2.575.714	0.001	0.007
7.8	71.344	0.005	0.012
7.9	71.344	0.005	0.012
8.1	2.223.265	0.021	0.004
8.2	82.140	0.019	0.005
8.3	82.140	0.010	0.005
8.4	65.712	0.005	0.001
8.5	32.856	0.011	0.004
8.6	246.420	0.012	0.005
8.7	328.560	0.007	0.007

Table 3.6: Case study raw data (own illustration)

a - activity-	R_a [EUR]	r_a [EUR]	s_a	δ_a	w
1.3	93.122	-	0.00	1.00	0.52
1.4	22.869	-	0.00	1.00	0.52
1.6	686.370	541.034	0.48	-	0.52
1.8	59.286	-	0.00	1.00	0.52
1.11	259.443	-	0.00	1.00	0.52
1.12	1.428.559	1.126.068	0.48	-	0.52
2.2	175.215	-	0.00	1.00	0.52
2.3	263.213	-	0.00	1.00	0.52
2.4	211.448	-	0.00	1.00	0.52
2.5	122.339	-	0.00	1.00	0.52
2.7	226.422	-	0.00	1.00	0.52
3.2	712.888	561.938	0.48	-	0.52
3.5	338.480	-	0.00	1.00	0.52
3.6	1.867.173	1.471.808	0.48	-	0.52
3.9	12.345	-	0.00	1.00	0.52
3.10	85.902	-	0.00	1.00	0.52
4.1	969.606	764.297	0.48	-	0.52
4.5	213.825	-	0.00	1.00	0.52
4.8	1.852.104	1.459.929	0.48	-	0.52
5.2	241.434	-	0.00	1.00	0.52
5.5	230.119	-	0.00	1.00	0.52
5.9	40.885	-	0.00	1.00	0.52
5.13	9.648	-	0.00	1.00	0.52
6.1	119.059	-	0.00	1.00	0.52
6.2	892.053	703.165	0.48	-	0.52
6.5	284.987	-	0.00	1.00	0.52
6.9	65.506	-	0.00	1.00	0.52
6.11	3.255.218	2.565.941	0.48	-	0.52
7.3	9.943	-	0.00	1.00	0.52
7.6	1.022.285	805.821	0.48	-	0.52
8.6	164.280	-	0.00	1.00	0.52
	∑15.8 million EUR	∑10 million EUR			

Table 3.7: Analysis for Δ=0.23 and G=10 million EUR (own illustration)

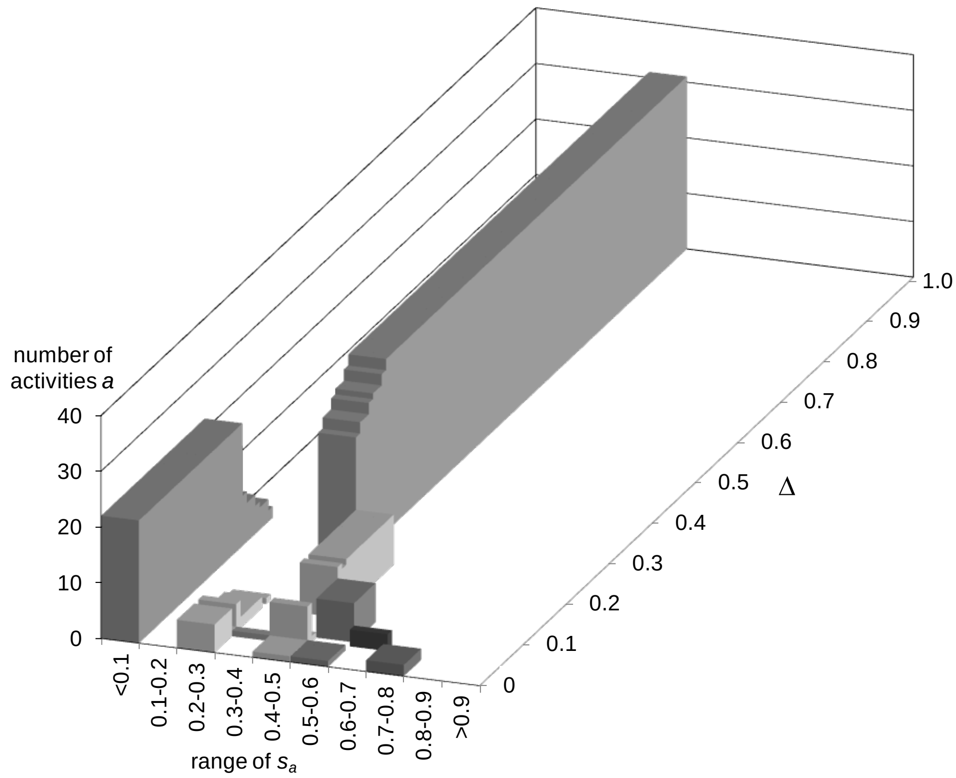


Figure 3.7: Distribution of s_a at 10 million EUR cost reduction (own illustration)

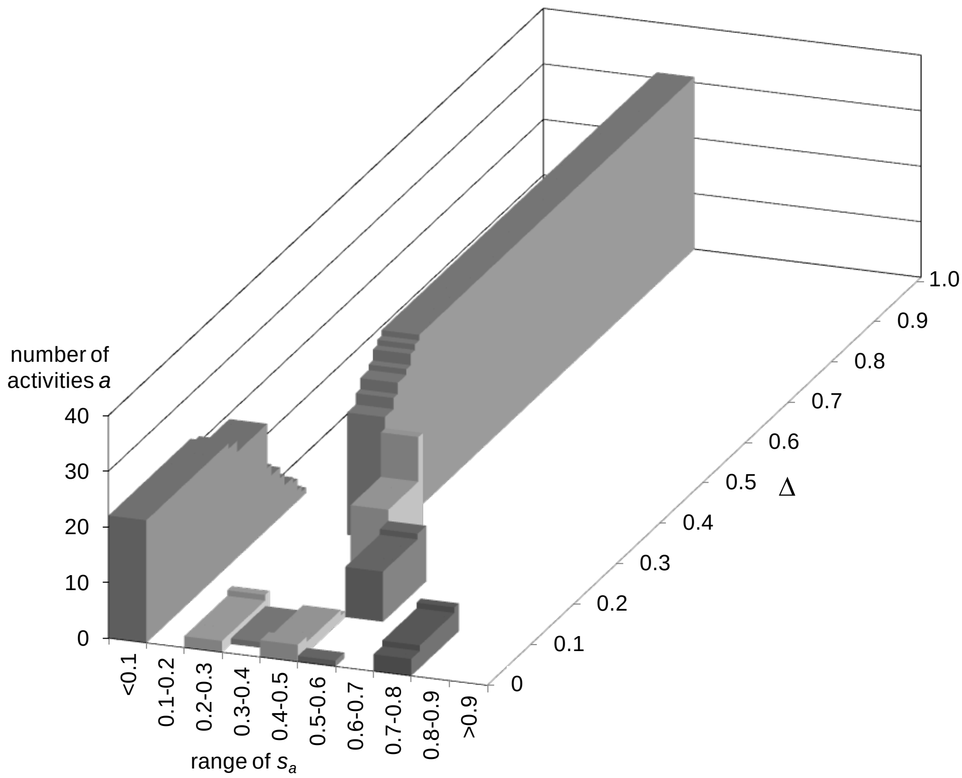


Figure 3.8: Distribution of s_a at 11 million EUR cost reduction (own illustration)

4 Where is the Success? Why the Success of Improvement Activities in Indirect Areas might not always be Identifiable – a Multiple Case Study Investigation

Indirect processes are gaining strategic importance: their total share of all business processes increases, especially in high technology and labour intensive industries, while at the same time less improvement potentials can be found in direct processes resulting from decades of optimization in direct areas. To stay competitive, companies are therefore demanding improvements in indirect processes. Yet, the success of these activities can often not be pointed out, especially from a financial perspective, which can have the same negative consequences as not being successful at all. The aim of this research is to determine those circumstances that are complicating a proper identification of improvements in indirect areas. For this purpose, a multiple case study of a global first-tier automotive supplier was set up comprising expert interviews, group discussions and a hypotheses evaluation process as empirical inputs for an in-depth analysis. The derived research insights enable companies to better identify the success of improvement activities in indirect areas as well as to support the achievement of improvements a priori. Therefore the research results can help companies to improve their market competitiveness.

Keywords: Indirect Processes, Continuous Improvement, Project Success, Middle Management

Pre-release: A proposal and a poster of this research were presented at the 9th Berliner Methoden Treffen 2013 (BMT2013) in Berlin.[20]

[20] The proposal is available at http://www.qualitative-forschung.de/methodentreffen/angebot/ps/2013.html#P2 (last accessed 04.03.2015).

4.1 Introduction

Continuous improvement programs striving for business excellence are gaining attention in indirect areas (Deiwiks et al., 2008), as companies are seeking for improvement of their business processes in total (Fehr et al., 2011). This is fostered as the share of indirect processes of all business processes is increasing (Renner, 2005; Moritz & Heiss, 2012) while at the same time potentials for improvement in direct areas are declining (Becker et al., 2007) and indirect processes are evaluated as entailing distinct potentials for improvements (Horváth & Partners, 2009; Schneider et al., 2011; Reinhart & Magenheimer, 2011). Pointing out the success of such improvement activities is of crucial importance and a major challenge at the same time (Schroeder & Robinson, 1991), especially in indirect areas (Fehr et al., 2011). This is reflected, for example, in the circumstance that the success of continuous improvement activities can actually mostly not be (monetarily) expressed in business practice (Davenport, 1993; Ozawa, 2007; Kamprath & Röglinger, 2011), even though involved individuals are mainly convinced of their success (Bernett & Nentel, 2010). If the advance of improvement is evaluated negatively, despite actual improvements, misled management decisions can cause the same negative consequences as not being successful at all. For instance, if improvement activities are pulped based on insufficient information, the market competitiveness of the organization might be at risk in the long run.

The monitoring of the success of improvement activities represents an important part in the maturity model of continuous improvement concepts (Bessant & Caffyn, 1997). Yet, continuous improvement research in indirect areas mainly focuses on success factors enhancing primarily the achievement of improvements (e.g., Schuh et al., 2012; Wald et al., 2013), neglecting or only superficially discussing possibilities how to determine the contribution of continuous improvement attempts to reach superior organizational targets. Also those specific tools that are applied in organizations to enhance the achievement of improvements in indirect areas such as activity-based costing (ABC; Cagwin & Bouwman, 2002), value stream mapping, analysis and design (Keyte & Locher, 2004) or key performance indicator trees (Donko, 2012) do not necessarily enable an identification of the success in business practice. Therefore and in respect of the efforts put into the achievement of improvements in indirect areas (Faust, 2009; Fehr et al., 2011; Schuh et al., 2012), an examination of those circumstances, that are causing the lack of ability to point out improvements appropriately is of high interest.

Organizations that take into account these circumstances can increase the probability for identifying success. A positive side effect is that the actual achievement of improvements is also facilitated. Consequently these organizations can strengthen their competitiveness. To ascertain such circumstances, a multiple case study was set up investigating improvement projects in indirect areas of a first-tier automotive supplier which were struggling to point out their success. The research question is: *Which circumstances are complicating the identification of the success of improvement activities in indirect areas?*

Considering that such circumstances have not been investigated in previous research, the specifics of continuous improvements in indirect areas in general will be reflected in the following, helping to set the research topic into context.

4.2 Literature Review

Indirect processes are those not characterized by directly value-generating activities; in other words, 'all other processes' that are required to keep the directly value-generating processes running (Thomas & Hemmers, 1981; Dellmann et al., 1994; Fehr et al., 2012). Under the idea of continuous improvement a large number of concepts have emerged (Berger, 1997; Caffyn, 1999; Bhuiyan & Baghel, 2005; Albright & Lam, 2006). They are characterized by the superior goal of waste reduction (Johnson, 1988) often proclaimed under the Japanese word *muda* (Womack & Jones, 2003) and the assumption that larger improvements can be reached by the sum of several small improvements (Bhuiyan & Baghel, 2005) in the sense of *kaizen* (Imai, 1986). In indirect processes continuous improvement is often rolled out in a similar way as in direct processes (Faust, 2009; Specht et al., 2011; Fehr et al., 2012). This is because most companies rolling out continuous improvement programs in indirect areas have already collected experiences in direct areas. The determining thought of doing so is that indirect processes can be handled in a similar way to direct processes. However, indirect processes are characterized by high levels of interdependencies and often driven by individual and less structured tasks (Becker et al., 2007; Schuh et al., 2013; Magenheimer et al., 2014), making an appropriate determination of cause-effect correlations difficult. The major medium of exchange between indirect processes are intangible information, often loosely structured and of informal character (Keyte & Locher, 2004). Furthermore continuous improvement initiatives in indirect areas are often implemented on a project basis (Schuh et al., 2012) associated with a potential broad range of perspectives to be covered (de Wit, 1988; Belassi & Tukel, 1996). Therefore the identification of the success of improvements in indirect areas is a challenging task, which requires specific management attention to be examined appropriately.

4.3 Methodology

The case study proceeding is of inductive character, driven by the idea that more or less failed projects allow investigators to gain fertile insights if the reasons for the mistakes made are determined (de Wit, 1988). If these faults are studied properly, organizations can gain sustainable competitive advantages (Edmondson, 2011). Yet, only few are trying to learn ex-post from such situations (Williams, 2004). The need for the chosen case study proceeding is also underlined by the circumstance, that it would be likely that most organizations potentially addressed in a survey, would have talked about successful activities (in the sense that the success also materialized), rather than improvement attempts whose success is not identifiable (and which might be considered as a failure). This would have made it impossible to expose those factors that are hindering success identification. It was possible to build the examined cases with the cooperation of an organization – a national EFQM award-winning and ISO/TS 16949 (based on ISO 9001 including continuous improvement) certificated first-tier automotive plant.

A multi-step proceeding has been used to study the problem. This allowed the assessment of widespread data at different points in time as well as a multistage analysis proceeding. By doing so, a high validity level of the research results has been ensured. The procedure is divided into five steps, as outlined in Figure 4.1.

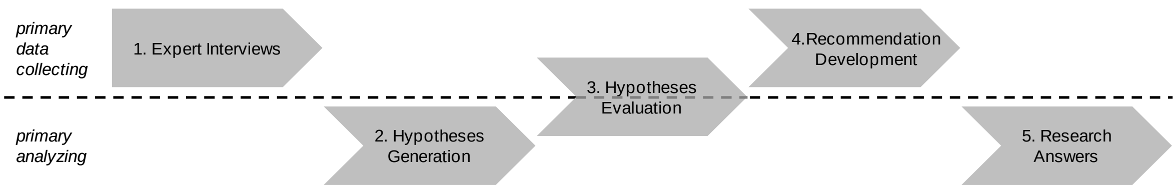


Figure 4.1: Method steps (own illustration)

1. Expert Interviews

A holistic multiple-case design (Yin, 2009) has been used to analyse the problem in the first instance. Besides collected background information, problem-centred expert interviews were conducted, and used as the primary source of information for further analysis (Mayring, 2002). As the interviews are of systematizing character (Littig, 2011), a semi-structured guideline has been used to ensure a well-conducted proceeding, but which still allow flexible reactions.[21]

The sampling requirements of the cases, derived from the research goal (Lamnek, 1995), were improvement activities that were examined within an indirect area, but whose success could not be pointed out by the respective middle manager in a way recognisable by the senior management. The middle management is of particular importance in this context: the coordination and supervision of continuous improvement projects is often in its field of responsibility (Gundogan et al., 1996; Klagge, 1996; Roth, 1998; Jørgensen et al., 2003) and therefore also the reporting between the operative examination of the improvement activities as well as the legitimisation towards the strategic management, and vice versa (Pheng & Hou, 2008; Mannel & Gerds, 2009*)*. The activities were initiated within a project context and embedded into an organization-wide improvement program. The required knowledge to develop the sampling strategy has been gained during collaboration within the cooperation organization (Mayer, 2002) by building up a quasi-expert knowledge level (Littig, 2011). In order to conduct all relevant information about the cases, one representative employee (EE) and their respective lower manager (LM) beside the middle manager (MM) were interviewed. This was in order to understand the group structure and correlations, as the success of improvement activities, even though mostly indicated within a top-

[21] It should be pointed out that although interviews are one of the most important information sources within case study research, the conceptual literature concerning expert interviews is limited (Meuser & Nagel, 2005).

down proceeding in large organizations, mainly depend on human factors (Picot & Frank, 1995; Cooke-Davies, 2002; Pande et al., 2007; Mayer & Brenner, 2009). Two projects within three indirect departments (quality management – QM; logistic – LO; and technical engineering – TE) were examined. Consequently, 18 interviews were held, as shown in Figure 4.2.

TE						LO						QM					
P1			P2			P1			P2			P1			P2		
MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE

Figure 4.2: Interview sample (own illustration)

By ensuring the sampling requirements, the validation of the interview partners as experts was ensured (Meuser & Nagel, 2005; Bogner & Menz, 2005; Helfferich, 2011). At the point of examination, the improvement project initiations were between six months and four years in duration (see Figure 4.5). With one exception, the initial manager and employees were in charge throughout.

The interview guideline has been developed based on theoretical preliminary considerations and insights gained during discussions with continuous improvement experts and managers of the cooperation organization. As the focus of the analysis is on organizational internal knowledge, a permanent control and a slight adaption of the assumptions was necessary during the research project (Meuser & Nagel, 2005). As suggested by Mayer (2002), in order to conduct all relevant aspects, as well as to increase the construct validity, dimensional analyses were used to develop the guideline (see Appendix 4.7.1 for an example). The dimensions and the respective request questions (Helfferich, 2011) were clustered into a cascade of topics, ranging from ample to detailed. To gain insights about the specific coherences ranging over the hierarchy, some questions were addressed asking for the perspective of the respective involved (indicated by an x), as shown in Figure 4.3 (see Appendix 4.7.2 for the complete guideline).

Topic	Dimension	Request question	Evaluation different perspective
Framework			
	Success		
		How would you define success within this project?	**X**
		...	
Action			
Interaction			
Individual			

Figure 4.3: Shortened interview guideline (own illustration)

Furthermore, an estimation on a four point Likert scale was requested, asking for an evaluation of the expectations and results with respect to the improvement of the criteria ‘quality’ (Q), ‘costs’ (C) and ‘delivery’ (D) in relation to the performance of the improved indirect activities (see Appendix 4.7.3 for the scale).[22]

Before the interviews were held, two pretests (Mayer, 2002) were conducted, which led to a slight adaptation of the used guideline. The interviews were recorded and transcribed literally afterwards, as is commonly required when organizational internal knowledge is studied (Meuser & Nagel, 2005). To do so, the permission of the experts was requested in advance. This was possible for all interviews, with the exception of two; for these two, it was necessary to conduct a summarizing transcription afterwards based on written notes made during the interviews and memory. The transcriptions were sent to all experts afterwards asking if any changes were required; none of the respondents asked for changes. The duration of the interviews lasted between 30 and 70 minutes, with an average of 45 minutes.

2. Hypotheses Generation

To identify the supra-individual commonalities within the analysing process, the concept of qualitative content analysis was applied (Meuser & Nagel, 2005). Qualitative content analysis is a primary concept, rather than a standardized one (Littig, 2011); it allows the ordering of text elements with specific aspects of meaning, with the superior goal of a systematic description of the texts’ meaning (Rustemeyer, 1992). To do so, a category system has been generated in a mixed inductive–deductive proceeding; this entails aspects from the guideline working as a deductive framework, alongside inductive aspects generated while going through the material using a back coupling process (Mayring, 2000). The used guideline defines its relevance in this step, as it facilitates the comparability of insights garnered from the interviews (Meuser & Nagel, 2005). The category system, the definition of allocation rules and common examples can be found in the Appendix (see Appendix 4.7.4). By doing so, the content analysis represents an empirical and methodical controlled analysing process within this research, bearing in mind the inductive developed categories (Mayring, 2000). Considering that there has not been any research related to this specific question to build on, this proceeding has demonstrated its appropriateness in the case context. Content validity has been ensured by applying the category system. To ensure the reliability of the proceedings, the material was categorized at two different points of time, with a one year break in between (otherwise known as intra-coder reliability). Other conceivable approaches to ensure the validity, such as the categorization by a third party researcher, were not applicable as the primary data are highly confidentiality. Aside from the classical proceeding of coding the text

[22] As elements of the magical triangle, which represents besides critics an important performance measurement basis in the cooperation organization (Skinner, 1969; Picot & Franck, 1995; Atkinson, 1999). Regarding the selection of the examined cases it should be mentioned that it was not the main goal of all of them to reach cost improvements. But all experts, beside one exception, stated that the improvement of costs was an expectation. Furthermore it can be assumed that it is expected that all improvement activities within the cooperation organization are generating a measurable monetary benefit.

material respective to the developed categories, critics Gläser & Laudel (2010) have considered extracting text elements outside of the categorization so as to prevent too rash a detachment from the original material.

To detect a starting point for deeper analysis about the functionality of the social system (Meuser & Nagel, 2005), cross-case analysis was applied, using the filled and not-filled categories as indicators. If no contra indicating category was filled, the specification of at least two experts in one project was considered for approval. By doing so, objectivity within the analysis process was ensured, as it was not simply based on first impressions gained during the data collection process. The following cross-case analysis strategies were used in order to do this (Yin, 2009; Gläser & Laudel, 2010):

- Accordance over the cases
- Specific individual cases
- Reasons for the same effect
- Same condition, different effect

Based on the identified starting points for detailed (single) analysis, a causal chain framework (Gläser & Laudel, 2010) representing a simple logic model (Yin, 2009) has been used in most cases to structure an in-depth analysis and to facilitate the replicability (see Figure 4.4).

Figure 4.4: Causal chain (own illustration)

In the analysis process, the respective categories from the identified cases were classified in the respective dimensions, and complemented, if helpful, with extractions from the original material. The analysis reached across the hierarchy levels. Hypotheses were derived based on analyses covering the detected cause-correlations, and in order to identify circumstances explaining why success could not be identified.

3. Hypotheses Evaluation

To increase the communicative and intra-organizational validity, the hypotheses covering the circumstances relating to why the success could not be identified were evaluated by six experts (two senior, three middle and one lower manager) of the cooperating organization (which were not a part of the primary sample). The selection of the experts was based on their personal and professional qualifications gained throughout their career. Only managers were considered in an attempt to prevent a discussion driven by hierarchical power (see Appendix 4.7.6 for an overview of the experts). The hypotheses were initially evaluated individually on a Likert scale, and then in a group discussion process. Within the group discussion process, it was permitted to locate hypotheses between the gradations of the Likert scale; if this had not been the case, the discussion would have been endless (although a quadrinomial Likert scale was initially chosen to force the experts to decide whether to confirm the hypotheses or not). To encourage the discussion, the developed hypotheses were tightened slightly (see Appendix 4.7.7 for the scale and the tightened hypotheses). After the approvals were received, the discussion was recorded and its main insights literally transcribed so as to be used within the analysing process, and thus to gain further insights into the research question (see Appendix 4.7.8).

4. Recommendation Development

The expert group was split into two groups after the hypotheses evaluation to develop recommendations on how to support the appearance of the approved hypotheses (so the identification of successes would not be hindered), and to ascertain why these recommendations should work. After this was done, the two groups presented their results bilaterally in poster form. In a final group discussion, the hypotheses' recommendations were respectively graded in a matrix regarding their factor of efficiency to ensure the identification of success, and the respective effort for ensuring implementation. The hypotheses evaluation and following group discussion lasted two hours.

5. Research Answers

Based on the cross-case analysis (using the causal chain framework based on the results of the qualitative content analysis) and the gained empirical insights (hypotheses evaluations discussion and developed recommendations), the circumstances that have caused the inability to point out the success of the improvement activities in the observed cases of the cooperating organization are derived in respect to the research question '*Which circumstances are complicating the identification of the success of improvement activities in indirect areas?*'.

4.4 Results

1. Expert Interviews

The level of improvement was evaluated, with one exception below expectation in terms of each project on the Likert scale (Q, C and D). Some improvements have been noted for all projects, as shown in Figure 4.5, where the bars of Q, C and D indicate the experts' expectations respectively results on the improvement of the performance of the examined activities in terms of these indicators. It is remarkable that the employees expressed significantly higher expectations than the managers (one tailed Mann–Whitney test, significance level 0.05), but also display a more significant drop in these results. The evaluation of the effort/benefit ratio, and the re-election of the improvement project over the hierarchy, shows (as far as the statements could have been collected) no consistent perception within any project, although the difference might not always be this harsh. The evaluations have to be read from the top; for example: P1 LM – MM re-election of the TE department shows the evaluation of the lower manager is positive in relation to the perception of the middle manager towards the re-election of the project.

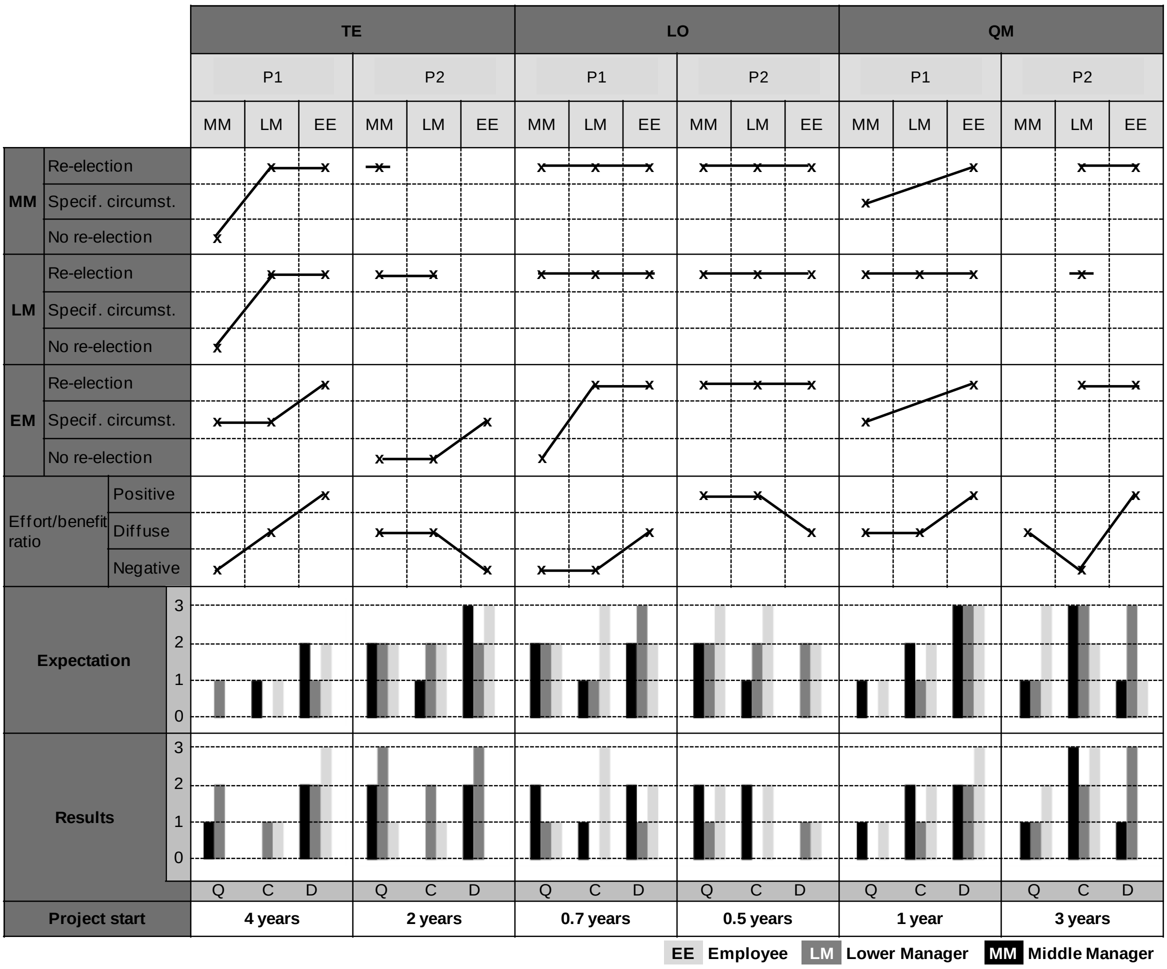


Figure 4.5: Case analysis (own illustration)

2. Hypotheses Generation

As a result of the analysis, and based on the cross-case analysis as well as the causal chain framework hypotheses have been developed. As an example, hypothesis 3 should be outlaid in detail. A detailed analysis of all other hypotheses can be found in Appendix 4.7.5.

<u>Collective target tracking</u> - Hypothesis 3

In each project (besides LO-P1) it was stated by the experts that a collective target tracking took place (category: group → target tracking → mutual target tracking), as indicated by the Xs in Figure 4.6 (specific individual case).

	TE		LO		QM	
	P1	P2	P1	P2	P1	P2
MM	X			X	X	X
LM	X	X		X	X	X
EE	X	X				X

Figure 4.6: Cross case analysis hypothesis 3 (own illustration)

The reaction that a non-collective target tracking could have, as reflected in the frictions in LO-P1, is shown in Figure 4.7.

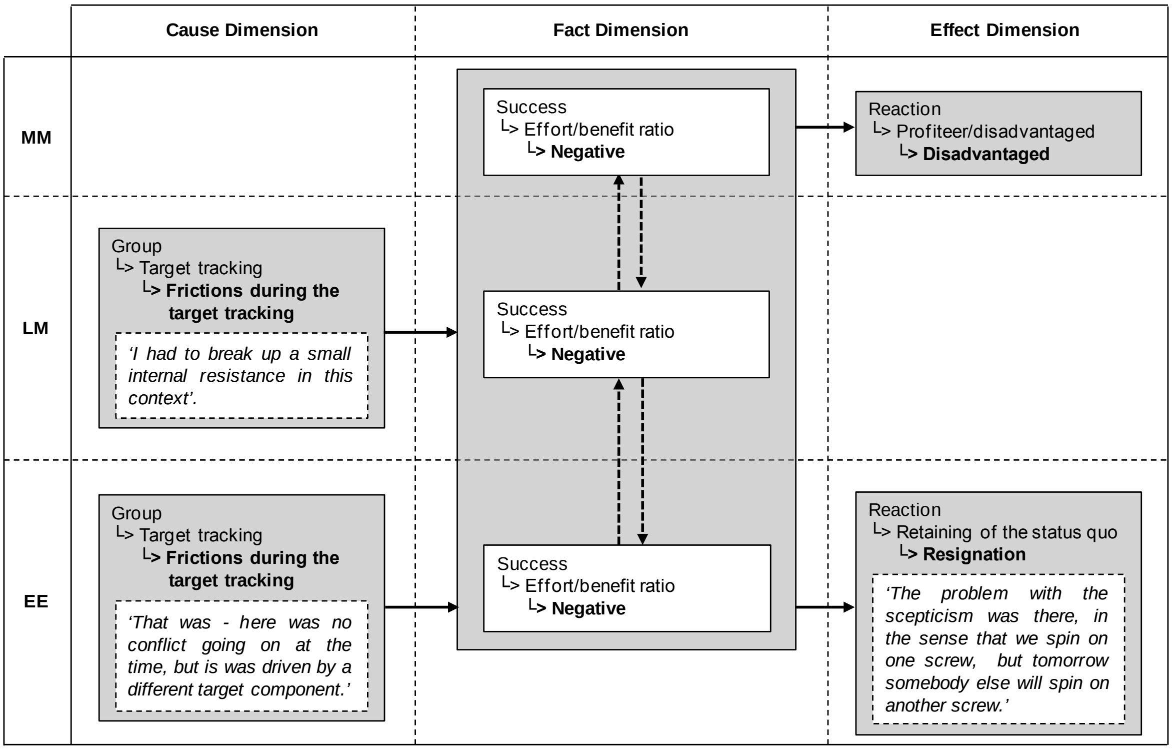


Figure 4.7: Causal chain hypothesis 3 (own illustration)

The employee and lower manager pointed out the problems associated with non-collective target tracking (cause dimension) within the project. This led to non-positive project evaluations (fact dimension), which are reflected in resignation respectively the perception of a disadvantaged project member (effect dimension). Therefore, the frictions caused by non-collective target tracking lead to a negative project perception, complicating any success identification within the project.

Hypothesis 1: *The generation of transparency is a pre-step in the course of reaching cost-effective improvements, rather than the final goal.*

Hypothesis 2: *A consequent materialization of generated rationalization potentials is required to prevent the effect of diffusion.*[23]

Hypothesis 3: *A collective target tracking is crucial to prevent a negative project perception.*

Hypothesis 4: *A sufficient information exchange is important to ensure a project's continuation.*

Hypothesis 5: *To avert resentment towards the improvement method, a reflective selection of a project is crucial.*

Hypothesis 6: *Sufficient freedom is of crucial importance to keep improvement activities going.*

Hypothesis 7: *An embedding in the strategic goal deduction process is important to ensure a large scope for improvement activities.*

Hypothesis 8: *A common understanding of success is crucial to reach any success.*

3. Hypotheses Evaluation

The results of the hypotheses evaluation step are shown in Figure 4.8. The average values of the single evaluations are shown in the dashed circles; the darker circles represent the results of the group discussion. In order to proceed further, the hypotheses have been taken as approved, and evaluated with at least partial agreement. It is remarkable that hypotheses 7 and 8 received distinctly less agreement during the group discussion – and hypothesis 8 even slipped out of the area of agreement – while hypothesis 2 received more agreement. But as there is no significant difference between the two groups (two tailed Mann–Whitney test, significance level 0.05), the results of the group discussion have been used for the further discussion. This was preferred because otherwise the analysis process fostered by the positive group dynamics could have been potentially disturbed.

[23] The effect of diffusion should mean actual improvements – especially working-time rationalisations – are no longer identifiable, even if they have been identified before. A separation towards the theory of diffusion in the innovation (Rogers, 1995), as well as organizational research, should be pointed out (Meyer & Rowan, 1977). Rather the term should express the observations with a meaningful apprehension.

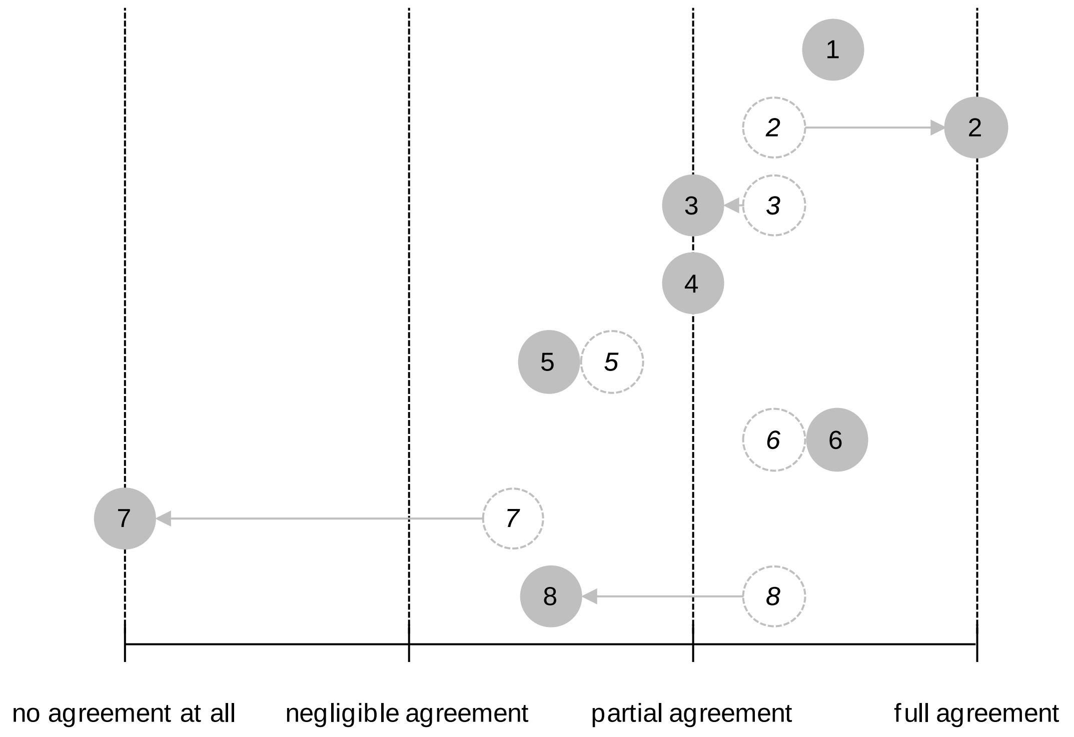


Figure 4.8: Hypotheses evaluation (own illustration)

4. Recommendation Development

For each confirmed hypothesis, at least two aspects have been worked out within the group discussions, which should support the occurrence of the hypotheses. All of the recommendations and respective explanations can be found in the Appendix, as well as the placement of the hypotheses and the respective recommendations in the efficiency/effort matrix (see Appendixes 4.7.9 and 4.7.10).

5. Research Answers

The circumstances are formulated as direct answers to the research question: 'The identification of the success of improvement activities in indirect areas is complicated, if...'

<u>Transparency</u> - Hypothesis 1

Whether or not transparency represents a success by itself depends on the kind of transparency aimed at and how it is handled (see hypotheses evaluation discussion – expert 5 in Appendix 4.7.8). However, as the transparency gained in all cases is mostly limited to the tracking of value streams, it should be assumed that transparency might merely be a pre-step on the way to reach identifiable improvements. The developed recommendations support this assumption as they suggest a definition of comprehensible performance measures able to build up a personal consternation with the respective managers and employees, which may be used for a further subsequent monitoring (see Appendix 4.7.9).

Circumstance 1: '...the creation of transparency is considered as the final outcome of improvement activities.'

Rationalization to prevent the effect of diffusion - Hypothesis 2

To prevent the effect of diffusion, the experts recommended two possibilities (which had already emerged during the hypotheses evaluation discussion): using acquired resources to cover upraising workloads within the case of business growth; or to bundle resources in order to rationalise them more easily in the case of competitive pressure (which can be considered as more interesting in terms of the research context). The necessity to do so seems obvious, but considering the occurrence of the diffusion effect in each case, it underlines the importance of extracting this specific circumstance.

Circumstance 2: '...the effect of diffusion is not prevented.'

Collective target tracking - Hypothesis 3

If non-collective target tracking hinders the identification of successes in improvement activities (or not), this depends on the scope of the collective target tracking process (see hypotheses evaluation discussion in Appendix 4.7.8). But considering the described resignation perception of the disadvantaged project member within LO-P1, as well as the conceivable threat of self-rationalization raised in the recommendations (see Appendix 4.7.9), despite not having been observed in the cases, the importance of collective target tracking can be considered crucial.

Circumstance 3: '...non-collective target tracking takes place.'

Insufficient information exchange - Hypothesis 4

An insufficient information exchange can have negative consequences: nobody recognises the improvement activities (see hypotheses evaluation discussion – expert 3 in Appendix 4.7.8), thus leading to a hindering of the project continuation (as in project L-P1). The recommendations – which are intended as a formalised proceeding to ensure enough information exchange with improvement projects – underline the importance of this.

Circumstance 4: '...the information exchange is insufficient.'

Freedom - Hypothesis 6

Even though project members might acquire freedom for improvement activities on their own, by detecting a 'ray of hope' that facilitates their own workload (see hypotheses discussion – expert 1 in Appendix 4.7.8), enough freedom should be ensured by an appropriate capacity plan (see recommendations in Appendix 4.7.9). A limitation of freedom can be considered a serious threat to reaching identifiable improvements, as indicated by its presence in other projects beside QM-P2.

Circumstance 5: '...not enough freedom for improvement activities has been conceded.'

4.5 Discussion

It is notable that the underlying categories in the causal chains, which have been used as a basis to derive the hypothesis in step 3, were generated inductively, beside those of hypothesis 6 respectively circumstance 5. Therefore, the following contextualisation of the circumstances in the academic discussion is mainly unconnected to the dimensional analysis or other pre-considerations in the guideline development. Nevertheless, besides the fact that this supports the chosen qualitative approach to investigating the problem in a way that other valuable insights might not, three out of five circumstances (1, 3, 5) could be affirmed in the literature; and while circumstances 2 and 4 represent ‘expected’ circumstances according to talks with experts, they have not been taken up in the literature before in the same way.

Transparency – Circumstance 1

Besides undoubted positive (side) effects within indirect areas, the perception that transparency represents only a pre-stage on the way to (financial) success – being that it is often used as a basis for further monitoring activities – is in line with the insights of Berger (1997), and Picot and Liebert (2011). Furthermore, the idea that a personal involvement in the definition process of measurement systems should increase their acceptance is affirmed by Groen et al. (2012).

Rationalization to prevent the effect of diffusion – Circumstance 2

It is a challenging task to point out gained rationalization potentials, even though specific accounting instruments are installed, like for example ABC (e.g., Johnson, 1988; Hoozée & Bruggeman, 2010). Nevertheless, the observed effect of diffusion is not described in detail in the academic discussion.

Collective target tracking – Circumstance 3

Previous research has also indicated the crucial importance of a collective target tracking within projects (e.g., Leana & van Buren, 1999). Furthermore, the possible resignation perception of a disadvantaged project member as a result of a non-collective target tracking process is in line with the insights of Gevers and Peeters (2009).[24] Additionally, the proposed aspect of self-rationalization is described as a common obstacle to improvement activities (Robinson, 1990; Schroeder & Robinson, 1991; Waeytens & Bruggeman, 1994; van Dun & Wilderom, 2012).

Insufficient information exchange – Circumstance 4

A sufficient information exchange is generally considered an elementary aspect of performance enhancement within workgroups in the literature (Godard, 2001), particularly in the context of lean management (Kaye & Anderson, 1999; van Dun & Wilderom, 2012). However, although seemingly

[24] The accordance to reach (temporary) collective targets can be conceived under the investigated aspect of ‘temporal consensus’ by Gevers and Peeters (2009).

reasonable, the conflicting conclusions observed in the case analysis, and which therefore supply input in the respective circumstances, could not be confirmed in the academic discussion.

Freedom – Circumstance 5

The assumption that sufficient freedom is necessary to allow improvement activities is described by Waeytens and Bruggeman (1994) and is also seen as an important leadership task in the context of improvement work by Kaye and Anderson (1999) and Schuh et al. (2012). Furthermore, the recommendation of managers and employees' engagement at all levels within the process so as to achieve (continual) improvements is in the line with the call of Caffyn (1999).

Considering the original approach of this research – to identify whether or not certain circumstances complicate the identification of improvement activity success – it should be noted that the confirming characteristic of the previous results rely mostly on general aspects of successful improvement activities and projects focusing on research, and should be interpreted as the following: if the occurrence of the circumstances is prevented, not only will the identification of success be supposedly ensured, but the primary achievement of any success could also be enhanced as well. The results enrich the understanding of improvement activities in indirect areas by investigating an obvious but so far scarcely studied problem.

The fact that hypothesis 7 was not confirmed by the experts is remarkable, especially considering the statement of nearly all the experts during the interviews; they agreed that there was no current implementation of a strategic goal deduction process, despite a manager normally being expected to be aware of the need for an implementation of improvement activities on an operational basis as part of the strategic goals of an organization.

4.6 Conclusion

This research increases organizations´ ability to check for the success when conducting improvement activities in indirect areas and therefore strengthen the clout of their improvement activities. Yet the insights can also be of interest for organizations that have already initiated improvement activities in indirect areas; for instance, if they are not able to identify the success of their activities, but are convinced that they are actually successful, they can put their proceedings to the test. This can be done by critically reflecting their improvement proceeding in regard of the derived circumstances. The goal is to detect starting points for an elimination of potential pitfalls hindering a proper identification of success. By doing so, the company and respective managers may prevent wrong decisions caused by incorrect information.

Even though the research focuses on the specifics of indirect processes, the results might also be of interest for improvements in direct areas. Especially in those processes driven by high complexity levels, potentially causing the same difficulties to detect cause-effect correlations as in indirect areas.

Although the developed findings are based on a rigorous research proceeding, qualitative data mostly allows different interpretations, especially in complex systems in which a variety of factors could have an influence on the observed effects. For that purpose it would be of interest to validate the results either in further longitudinal studies, or in a quantitative empirical setting using the gained insights as a basis. Nevertheless, as the expert discussions and the contextualisation have shown, the results represent a valuable addition to the body of knowledge on improvement activities in indirect areas, the importance of which continues to gain ground.

4.7 Appendix

4.7.1 Dimensional Analysis of Motivation

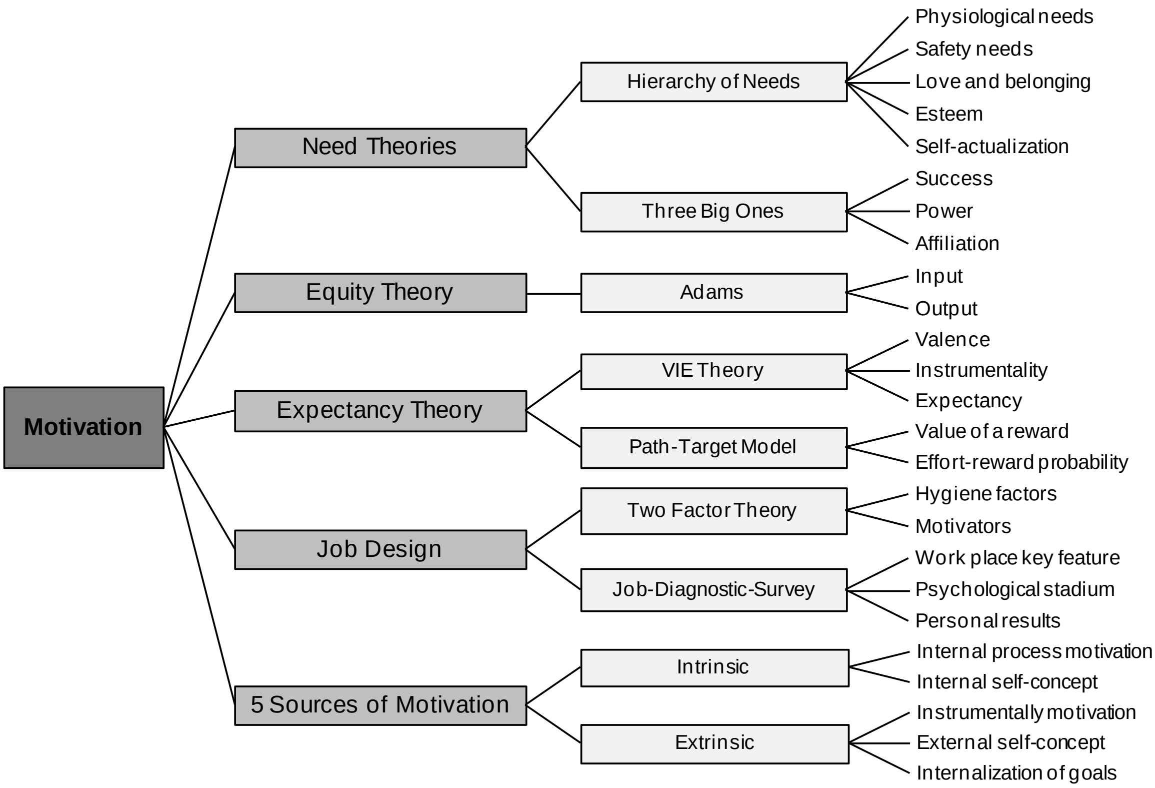


Figure 4.9: Dimensional analysis of motivation (based on Ramlall 2004 and Barbuto & Scholl, 1998)

4.7.2 Interview Guideline

Topic	Dimension	Request question	Evaluation different perspective
Framework			
	Success		
		How would you define success within this project?	**X**
		Please evaluate the expectations of the project regarding the criteria quality, cost, delivery.	
		Please evaluate the results of the project regarding the criteria quality, cost, delivery.	
		How would you evaluate the effort/benefit-ratio of the project?	
		What does ‘improvement’ mean from your perspective?	
		How is it possible to determine the success of the project from a financial perspective?	
	Classification		
		How would you describe the situation before and after the examination of the project?	**X**
		Which effects did the project have on upstream respectively downstream processes within the organization?	
		How would you classify the project in an organizational context?	
	Selection		
		What has been the crucial reason for choosing the project?	
		Would you choose the same project again? If so, why; if not, why not?	**X**
Action			
	Proceeding		
		Did you follow a specific proceeding during the project?	
		Have you been confronted with organizational difficulties during the project?	
	Method		
		Have there been specific assignments of roles and responsibilities within the project?	
		Have you been familiar with the methods required to perform the project?	
Interaction			
	Group		
		Have the project targets been collectively followed?	
		Has there been a momentum within the group after the initiation of the project?	
		Could you identify different kinds of project members?	
	Leadership		
		Did you have enough freedom within the project?	**X**
		What kind of support did you receive within the project?	**X**
Individual			
	Motivation		
		How did you become a project member?	**X**
		How would you describe your motivation at the beginning and at the end of the project?	**X**
	Reaction		
		Have you been confronted with the possibility of a loss of tasks or competences?	
		Do you have the perception of being a profiteer or a disadvantaged?	

Table 4.1: Interview guideline (own illustration)

4.7.3 Likert Scale Criteria ‘Quality’, ‘Costs’ and ‘Delivery’

		does not apply			does apply
		0	1	2	3
Please evaluate the expectations of the project regarding the criteria quality, cost, delivery.	Q				
	C				
	D				
Please evaluate the results of the project regarding the criteria quality, cost, delivery.	Q				
	C				
	D				

Figure 4.10: Likert scale (own illustration)

4.7.4 Category System

Those categories that have not been met in the analysis process can be identified by the fact that no typical example is provided. The addition – over the hierarchy – indicates that the categories have been filled with information about the specific coherences ranging over the hierarchy (asking for the perspective of the respective involved others). The common examples extracted from the original transcribed material have been translated from German to English in the following.

Main category	Category	Subcategory	Sub-sub category	Category definition	Typical example	Expert
Success						
	Description of improvement					
		Improved controllability		The controllability of the examined process has been improved, representing (one part of) the success of the improvement project.	*'I have a tool at hand to calculate […] what has an impact on my required personal capacity […].'*	LO-P1-MM
		Reduced firefighting		The reduction of firefighting activities allows further improvement and other supporting activities to be focused on.	*'[…] functions which we actually have to fulfil were not examined if they did not have an emergency priority, as we were busy with firefighting. If the project is finished we might be able to stem this.'*	LO-P1-EE
		Improved coordination				
			Upstream	The coordination with upstream functions/processes is improved.	*'Improved coordinated work with other […].'*	TE-P2-MM
			Down-stream	The coordination with downstream functions/processes is improved.	*'We are depending on development department documents […] if we get them in the right way we can reduce the efforts required […].'*	TE-P2-EE
		Generation of structure		The ongoing processes are more structured than before.	*'But I think it is a success if I design my directives in a way that they all fit together without any disruption.'*	QM-P1-LM
		Reduction of non-value-adding activities		Activities which are not value generating are eliminated.	*'[…] does not examine any useless work. So we […] atomized the system, so it can load itself with the required data.'*	LO-P2-MM
		Stan-dardization		The examined processes are standardized and therefore an easier handling is possible.	*'As I said, the success is that I have a standardized process, which is consistently examined within the cooperation, therefore I don't need to ask contextual questions about how to examine the process. So I can focus on my processes, or more precisely on my variations.'*	QM-P2-EE
		Changed sequence		As a result of the project the pre-existing process order/proceedings has /have been changed, which is perceived as an improvement.	*'There have been massive changes in the structure and the proceedings.'*	TE-P1-LM
		Generation of transparency		The generation of transparency is described as a success by itself.	*'I have never seen what I am doing during the day and during the whole week in such a transparent way.'*	LO-P2-MM
		Same job but easier, quicker and with less effort		The same job can be done easier, quicker and with less effort.	*'The success represents the reduction of the personal time effort and the reduction of the contextual as well as functional efforts to examine the job.'*	QM-P2-LM

		Same job done faster with the same staff	The same job can be performed faster with the same number of staff.	*'The costs are the same, but I can handle more orders at the same time than before.'*	TE-P1-EE
		Grow together during the project	The project members developed their personal and team skills further during the project within a bilateral process.	*'From my perspective a very positive side effect of the project is that the employee further developed his skills.'*	LO-P1-MM
	Point in time of success realization				
		Quick success with low effort, further achievements difficult to reach	The first improvements have been achieved quickly, while further improvements have been difficult to reach.	*'We have started […] we wanted to improve […] but at some point it became difficult […].'*	QM-P1-EE
		Success can only be seen in the long run	The success of the improvement activities can only be seen after a while.	*'Not negative, but I say it will take some activation time before we will get some money back […].'*	TE-P1-MM
	Success assessment – over the hierarchy		Mutual success assessment over the hierarchy.	*'The success for the employees? An improvement in the key indicators like lead time as well as the generation of transparency [...].'*	QM-P2-MM
	Quantification				
		Result	Comments during the evaluation of the results of the improvements on the Likert scale regarding the parameters quality, time and cost, from their own perspective and the other project members.	*'Regarding the cost topic, we have not achieved anything. Regarding topic delivery and delivery quality we are within the range of expectation, we have improved.'*	TE - P1-MM
		Expectation	Comments during the evaluation of the expectations of the improvements on the Likert scale regarding the parameters quality, time and cost, from their own perspective and the other project members.	*'I would say a 2, because a time saving can definitely be identified.'*	LO-P2-EE
	Effort/benefit ratio				
		Positive	Positive estimation of the effort/benefit-ratio.	*'The advantages are very good […] the effort from a financial perspective […] was not high from our perspective, as we did it ourselves […].'*	QM-P1-EE
		Negative	Negative estimation of the effort/benefit-ratio.	*'The effort was tremendous […] if you were to calculate it from the factors we reached, you would have no chance.'*	TE-P1-MM
		Diffuse	Diffuse estimation of the effort/benefit-ratio.	*'It´s difficult to tell, as I don`t recognize the benefits in my daily business […] unfortunately it is all very squishy.'*	LO-P1-EE

	Financial assessment					
		No possibility of financial determination		Determination of the financial benefits of the improvement activities is not possible.	*'I can`t measure the success of the project financially. I cannot measure it monetarily […]'*	TE-P2-LM
		Rationalization working time				
			Determi-nation not possible	The level of rationalized working time by the improvement activities cannot be determined.	*'I think on an employee level we will make time savings […] on the one hand they are hard to measure […] from the actual perspective we will not release any head count.'*	LO-P1-MM
			Actual rationali-zation of personal capacity	The level of rationalized working time can be summarized to at least one complete head count.	*'Within the quality management department the success might be displayed by a reduction of overtime or even by the reduction of a head count.'*	QM-P2-LM
			Redistri-bution	The rationalized working time is used to perform other jobs by the respective employee(s) within the organization.	*'It's not that the employees will twiddle their thumbs […], then they will do another job, we are quite flexible.'*	QM-P1-EE
		Contrary effects		The improvement activities might lead to increased costs in other areas of the value chain.	*'Under some circumstances, but very specific circumstances, this could lead to a cost increase on the supplier side [...].'*	LO-P1-MM
		No external charging of the improvement benefits		Even the outcome of the improvement activities represent a benefit for the customers, they do not get charged for it.	*'The customer gets their parts faster […] no, he doesn`t pay.'*	QM-P1-EE
		Resulting				
			Upstream	The financial success of the improvement activitie(s) can (possibly) be recognized in upstream departments.	*'With this project plan the development department has been asked to do so and some did it, some not […]'*	TE-P2-EE
			Down-stream	The financial success of the improvement activitie(s) can (possibly) be recognized in downstream departments.	*'It might be possible to calculate this by the production departments as they […] save costs.'*	QM-P2-LM
		Detailed segmentation		If all activities were to be tracked in a very detailed level, improvement might be able to be tracked.	*'So in principle it would be possible […] if we were able to start to determine how much effort has been spent on each separate task […].'*	TE-P2-MM
	Preference of indicators other than costs			The improvement of other indicators like quality or flexibility is preferred to cost improvements.	*'We need a specific flexibility in our department. […] I need a certain number of employees. […] we have to react quickly […].'*	QM-P1-EE
Classi-fication						
	Heteronomy			The department is controlled externally regarding their tasks.	*'(…] in that direction we are completely controlled externally. That means we don`t know today whether next year we have to handle more or less [jobs] than this year.'*	QM-P1-MM

Focus on own area			During the project the focus of the improvement activities has been completely on department internal topics.	*'So the result was, that we will take care of what we handle internally, what we can influence and improve, and that will be implemented, but we will not take care of the external topics.'*	QM-P1-MM
Situation description – over the hierarchy					
	Before		Situation description of the ongoing processes before the initiation of the improvement project, from their own perspective and the respective other project members.	*'Before the project examination there was always this topic of pointing towards the construction department […]'*	TE-P1-MM
	After		Situation description of the ongoing processes after the initiation of the improvement project, from their own perspective and the respective other project members.	*'Such small things have been settled […] it is clear who is in charge at which interface for the handover quality.'*	TE-P1-MM
Implications					
	No consideration		The implications on other areas have not been considered during the project.	*'The up- and downstream departments have not been considered within the procedure.'*	TE-P1-MM
	External		The project had implications for external entities.	*'But for each party there is more security, also for the supplier, maybe a little bit more manual effort is required, but […] it is clearly defined and everybody knows how the goods have to be packaged […]'*	LO-P1-LM
	Upstream areas				
		neither positive nor negative	The implications on upstream areas are neither positive nor negative.	*'So the impact is that […] the responsibilities have shifted a little bit.'*	QM-P2-EE
		Positive	The implications on upstream areas are positive.	*'As it takes place quiet and more levelled, the pre-chain became more calmed [...].'*	LO-P2-EE
	Downstream areas				
		neither positive nor negative	The implications on downstream areas are neither positive nor negative.	*'The implication for the other departments and involved people is that the process has to* led by [within?] a new structure*, which requires a learning process for them first.'*	QM-P2-MM
		positive	The implications on downstream areas are positive.	*'[...] as well as downstream processes.'*	LO-P2-EE
Organizational context					
	Department		The impact of the improvement project is contextualized within the range of the department.	*'So we* undertook it in our departments *[...} it is not disadva-tageous when you can present yourself and demonstrate what you do.'*	QM-P1-EE

		Site		The impact of the improvement project is contextualized within the range of the site.	*'From my perspective this project has great potential […] for the site it has great potential.'*	LO-P2-EE
		Company		The impact of the improvement project is contextualized on the company level.	*'What we do has – and I'm not exaggerating – a global impact.'*	LO-P1-LM
Selection						
	Reason for selection					
		Derivation from strategy		The selection of the object of the improvement project is based on a derivation from the strategy.	-	-
		Derivation at department level		The selection of the object of the improvement project is based at department level derivations.	*'The process […] was chosen as it was a trouble spot within the department […].'*	TE-P2-MM
		Enforcement		The project examination by itself has been more or less obtruded.	*'Right now everything is lumped together, every department runs a project.'*	QM-P1-MM
		Reason has changed		The original reason for the selection of the project is not valid any longer.	*'Yes, we started in the past […] that the economical situation has changed in such a way, could not have been predicted.'*	TE-P1-EE
		No target derivation		A pre-setting of targets at the beginning of the improvement project is not possible.	*'We are* a long way away from setting *targets and to say: if you do this and that, then you have to reach 10 per cent in indirect areas every year, every quarter year.'*	LO-P2-MM
	Opinion about project re-election – over the hierarchy					
		Re-election of the project		Would choose the project retrospectively again, believes estimates that the other project members would choose the project again.	*'I would choose the project again. […] Because I think that there is nothing more to improve.'*	TE-P2-LM
		Specific circumstances		Would choose the project retrospectively again under specific circumstances, believes that the other project members would choose the project again under specific circumstances.	*'The employee would like to repeat some steps of some parts […] if he would recognize them without the whole preparation work in the complete process, I would doubt.'*	TE-P1-MM
		No re-election of the project		Would not choose the project retrospectively again, believes that the other project members would not choose the project again.	*'Rather no, because the employees right now […] who are performing the task right now, have been doing this task for 20 years or even longer. So they are going to say, I've been doing it I that way since forever and there are standards.'*	TE-P2-LM
Procee-ding						
	Systematic of proceeding			Description of the proceeding during the project examination.	'So, specifically, *we found a method which allowed us to map the whole process […].'*	LO-P2-EE

	Organizational complications				
		Influenceable	There have been organizational complications during the project, which could actually have been prevented.	*'Yes, the implementation project has not been initiated […]* as the investment seemed too great*.'*	QM-P2-LM
		Non-influence-able	There have been organizational complications which have not been influenceable.	*'We have been confronted with several organizational problems […] we are not working with […] SAP and then we realized that SAP is the leading element at the site, but can hardly be configurated to meet our demands […].'*	TE-P1-EE
		Daily business	There have been complications during the project caused by challenges from the daily business.	*'We have defined it back then, but then the topic was postponed because of a hectic work schedule and then it was picked up again caused by the organizational change.'*	LO-P1-MM
		No complications	There have been no organizational complications during the project.	*'So afterwards everything had to be organized with appointments [..] that worked pretty well. So the cooperation was very good.'*	QM-P1-LM
	Restrictions caused by economic downturn		The examination of the improvement project lost momentum because of an economic downturn.	*'The situation has changed slightly because of the cost situation […] therefore improvement projects are now examined a little more slowly […].'*	LO-P1-MM
	Diffusion		Actual improvements, especially working time rationalizations, are no longer identifiable after a while, even where they have been identified before.	*'[…] that vaporizes in the big whole system.'*	LO-P1-LM
Method					
	Role definition				
		Have not been defined	Roles within the improvement project have not been defined in advance.	*'But we didn't sit down at the beginning and say: this is your task, that is yours, we didn't do that […]'*	LO-P2-MM
		Have been defined	Roles within the improvement project have been defined in advance.	*'Yes. There was a project owner […] he did the whole thing as a project leader and we got all the employees on board.'*	QM-P1-LM
	Methodology knowledge				
		Learning by doing	The required methodological competence has been acquired by the project group during the project.	*'Exactly, we just sat together and brainstormed what should be the content, what had to be included, what we needed, but that´s all from a technical perspective. And then we started a trial and error proceeding […].'*	LO-P1-LM

		Not enough methodology knowledge		There was not enough methodological knowledge (at the beginning) to perform the project.	*'At the beginning we didn`t have a lot of experience with the method […] I would appreciate more methodological support in such projects. So a systematic training of the employees at the beginning of such projects would have been useful.'*	TE - P1-LM
		Enough methodology knowledge		There was enough methodological knowledge to perform the project.	*'Overall I would estimate that the employees are familiar with it […].'*	QM-P2-MM
		Knowledge from daily business sufficient		The knowledge from the daily business was sufficient to handle the improvement project.	*'Let`s say basically this is […] his original job.'*	LO - P1-MM
	Limits of improvement logic			The application of improvement tools from production areas has some limitations in indirect areas.	*'[…] you have to be sure about what you actually want, whether the circumstances are known, whether the instruments that are being used are able to help to identify the underlying structure.'*	QM-P1-MM
Group						
	Target tracking					
		Frictions during the target tracking		During the project internal frictions appeared.	*'I had to break up a small internal resistance in this context.'*	LO-P1-LM
		Mutual target tracking		The project targets have been tracked mutually by the project members.	*'It is my observation that the team pulls together. That means, we want to realize the topic and the team does its best.'*	QM-P2-MM
	Types of group members			Description of the different types of group members.	*'Yes, we had a moderator [,,,] we had a secretary […] and one who took care of the process, like time frames and scheduling.'*	TE-P2-LM
	Group dynamics			Description of the different types of group dynamics.	*'No, so a sluggish animating was not required. But an intrinsically dynamic, it would not call to an intrinsically dynamic […] as it was restrained from external effects.'*	LO-P2-LM
	No regular feedback rounds			The communication within the improvement team on a regular basis was unsatisfactory.	*'I don't know if and how often this was shown in the group review meetings.'*	LO-P1-MM
Leader-ship						
	Freedom – over the hierarchy					
		Enough freedom		Project members had enough freedom to perform the project.	*'The employees had enough freedom to realize the project.'*	TE-P1-LM
		Partly enough freedom		Project members had partly enough freedom to perform the project.	*'So the employee had basically enough freedom. But he still had, as he has not been freed for the whole extent, gained more extra hours.'*	TE-P1-MM

		Not enough freedom		Project members had not enough freedom to perform the project.	*'The freedom was not enough, because of specific circumstances, external issues always led to new tasks.'*	TE-P1-EE
	Support – over the hierarchy			Description of the kind of experience and given support.	*'When I needed support I got it. […] From my lower and my middle manager.'*	QM-P2-EE
	Distance manager and operative project examination			The manager(s) within the project are distanced from the operative project examination to evaluate the success.	*'With the method used it is not possible to target the abstraction level of the site management. Therefore I can't meet the expectations of the site management.'*	TE-P1-LM
	Limited perception of the employees interest			The managers had the perception that the employees aren't /would not have been so interested in improvement activities.	*'We have all been surprised that he […] was very, very active. I didn't expect this. I had expected that I would have to motivate him constantly for this – from his perspective theoretical, not technical – topic.'*	TE-P1-MM
Motivation						
	Involvement – over the hierarchy			Description of how participants became involved in the project.	*'At the beginning the employees were especially curious, in the end they drove the project themselves.'*	TE-P1-LM
	Kind of motivation					
	Motivation at the beginning – over the hierarchy					
		High		Motivation level at the beginning of the project was high for one self or the other project members.	*'The motivation back then was very high, as I was put in charge as a new project leader […].'*	TE-P1-EE
		Middle		Motivation level at the beginning of the project was middle for one self or the other project members.	*'On a scale from one to six, I would say a three.'*	LO-P1-MM
		Low		Motivation level at the beginning of the project was low for one self or the other project members.	*'The motivation at the beginning was weak.'*	QM-P1-LM
		Not specified		Motivation level at the beginning of the project for one self o the other project members cannot be estimated.	*'Regarding the beginning I can`t evaluate that.'*	LO-P2-LM
	Motivation at the end – over the hierarchy					
		High		Motivation level at the end of the project was high for one self or the other project members.	*'My motivation is still high.'*	LO-P2-EE
		Middle		Motivation level at the end of the project was middle for one self or the other project members.	*'[…]meanwhile it is noticeable, that something has been organized and fixed. That is not so bad.'*	QM-P1-LM
		Low		Motivation level at the end of the project was low for one self or the other project members.	*'It is very low.'*	QM-P2-LM

		Not specified		Motivation level at the end of the project for one self or the other project members cannot be estimated.	*'I can't tell you.'*	TE-P2-EE
	Frustration			During the project frustration appeared.	*'It is frustrating if a bunch of tasks can`t be done because resources are restricted […].'*	QM-P2-MM
Reaction						
	Loss of tasks/ competences					
		Loss of tasks/ competences was feared		A loss of tasks/competences caused by the outcome of the project (e.g. shift of tasks to other sites) was feared.	–	–
		Loss of tasks/ competences was not feared		A loss of tasks/competences caused by the outcome of the project (e.g shift of tasks to other sites) was not been feared.	*'No, definitely not. Because within our department everybody sees more than enough of other construction sides […].'*	LO-P1-EE
	Profiteer/ disad-vantaged					
		Profiteer		The perception of the interviewee is that he benefits from the project.	*'As a profiteer, because I got an overview, specific standards have been reached and it is more transparent.'*	TE-P2-LM
		Disadvantaged		The perception of the interviewee is that he has suffered as a result of the project.	*'Right now I would say that it is an extra effort […].'*	LO-P1-MM
	Retaining of the status quo					
		Self-affirmation		Self-affirmation that the actual status quo will not change irrespective of the improvement project.	*'It has been, as I said, my conviction that not a lot will happen. But this is my personal conviction and nobody believed me.'*	QM-P1-MM
		Abuse of the method		The applied methods or the improvement project in total have been misused to enforce one's own will.	*'[…] if I could define what they should do, I would not have needed this project. But as I cannot dictate to the departments what they should do, I need a vehicle which I can use to convince my colleagues that this is right.'*	QM-P1-MM
		Resignation		During the project a sense of resignation emerged.	'There has been a problem with scepticism, *in the sense that we twist on one screw, but tomorrow somebody twists another screw and nothings fits any longer.'*	LO-P1-EE
		Visualisation to keep the status quo		A primary visualisation made to identify potential improvements has been abused to justify the status quo.	*'For me it was clear, if we have visualised it once […] then there can be no argument against a topic like this.'*	QM-P1-MM

Table 4.2: Category system (own illustration)

4.7.5 Hypotheses Development

Accordance over the cases

<u>Transparency</u>

	TE		LO		QM	
	P1	P2	P1	P2	P1	P2
MM	X	X	X	X	X	X
LM	X	X	X	X	X	X
EE	X	X	X	X	X	X

Figure 4.11: Cross case analysis hypothesis 1 (own illustration)

Over all cases, and even by each expert, the creation of transparency was named as one of the success elements of the projects. Therefore this found input in the category system (Success → Description of improvement → Generation of transparency). Even the creation of transparency can be considered as a positive (side) effect; the ‘over-interpretation’ of the effect of transparency can lead to a situation in which the involved project members might rest on the gained transparency rather than using it as a starting point for further improvements, as shown in the analysis of project TE-P1.

The gained transparency regarding the processes represents for each project member the success of the project. But this can’t be expressed financially (fact dimension). The reason why transparency plays such an important role for the managers of project TE-P1 is that they have the perception of being a game ball of up- and downstream departments (cause dimension). Therefore the gained transparency insights are perceived as a chance to prevent this for the future. As a result it is not possible to meet the perceptual level of the relevant senior management (effect dimension).

Hypothesis 1: The generation of transparency is a pre-step in the course of reaching cost-effective improvements, rather than the final goal.

TE-P1:

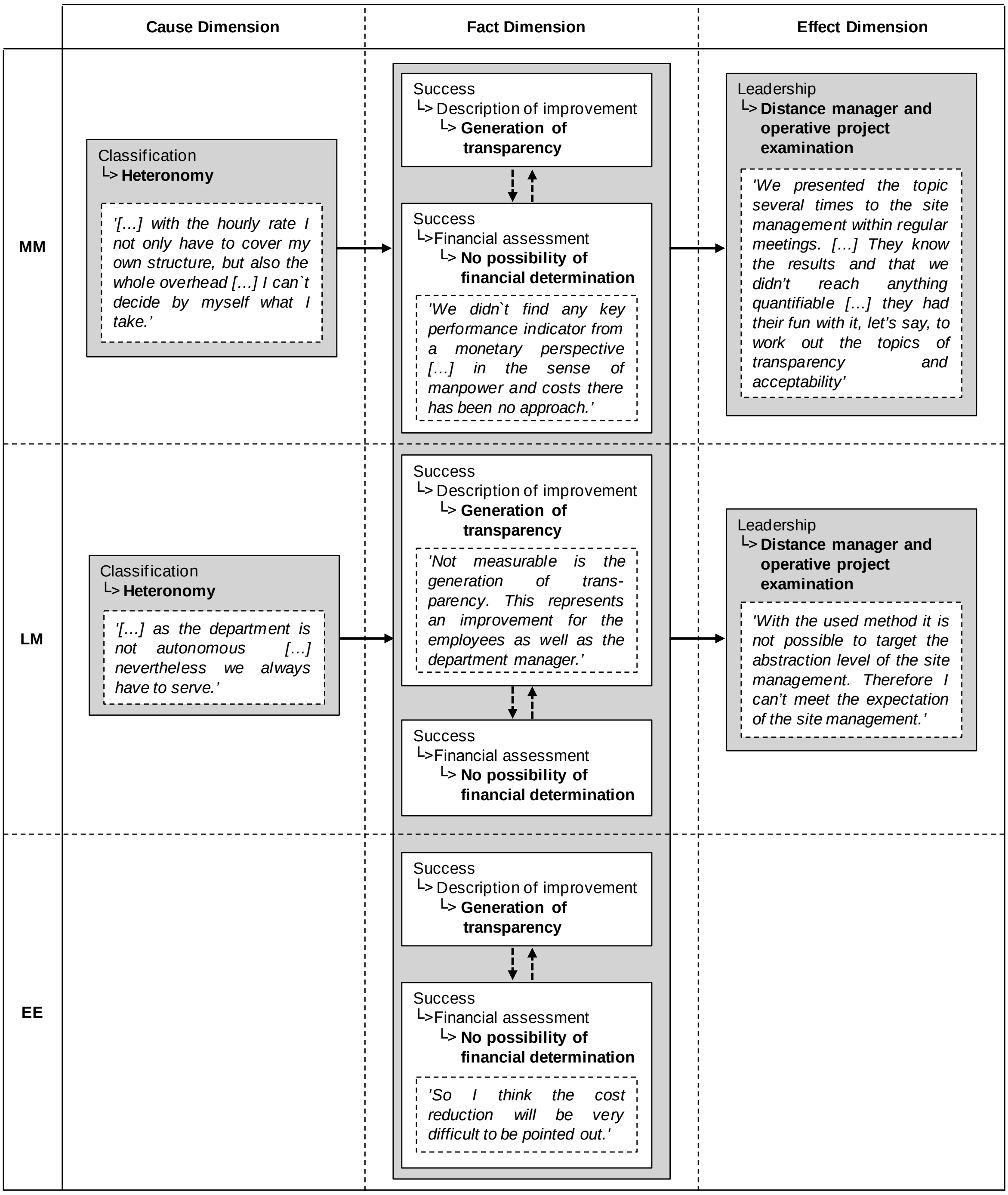


Figure 4.12: Causal chain hypothesis 1 (own illustration)

Specific individual cases

Rationalization to prevent the effect of diffusion

Diffusion

	TE		LO		QM	
	P1	P2	P1	P2	P1	P2
MM	X	X			X	
LM	X	X	X	X	X	
EE			X	X	X	

Figure 4.13: First cross case analysis hypothesis 2 (own illustration)

In all projects with one expectation, the effect of 'diffusion' has been recognized in particular. Within the process of categorization this effect has found input into the category system (Proceeding → Diffusion). The phenomenon becomes particularly clear in the presence of the following category constellation (e.g. QM-P1-EE):

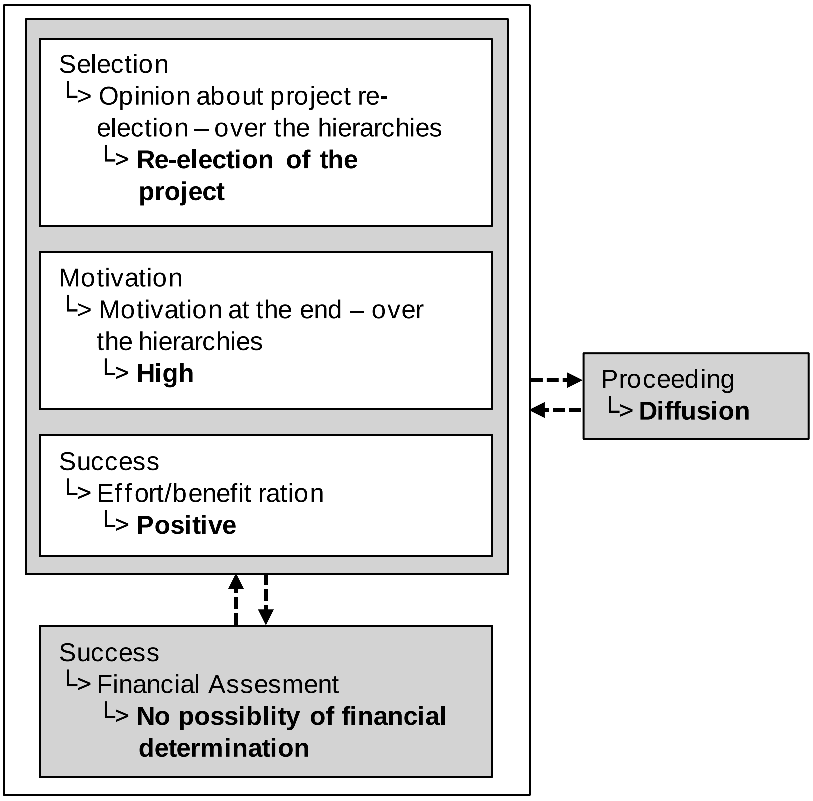


Figure 4.14: Causal chain hypothesis 2 (own illustration)

<u>Rationalization</u>

	TE		LO		QM	
	P1	P2	P1	P2	P1	P2
MM		X		X		X
LM						X
EE						

Figure 4.15: Second cross case analysis hypothesis 2 (own illustration)

At a closer look it is remarkable that the managers within QM-P2 perceive the rationalization of head count (in the future) as a potential approach to determine the financial impact of the improvement activities (Success → Financial assessment → Rationalization working time → Actual rationalization of personal capacity). Therefore this can be considered as an inhibiting reason preventing the phenomenon of diffusion and allowing the identification of success.

Hypothesis 2: A consequent materialization of generated rationalization potentials is required to prevent the effect of diffusion.

<u>Insufficient information exchange</u>

	TE		LO		QM	
	P1	P2	P1	P2	P1	P2
MM			X			
LM			X			
EE			X			

Figure 4.16: Cross case analysis hypothesis 4 (own illustration)

Within the project LO-P1 everybody pointed out the irregular information exchange (Group → No regular feedback rounds). Because of this, negative consequences for the further project examination can be the result.

LO-P1:

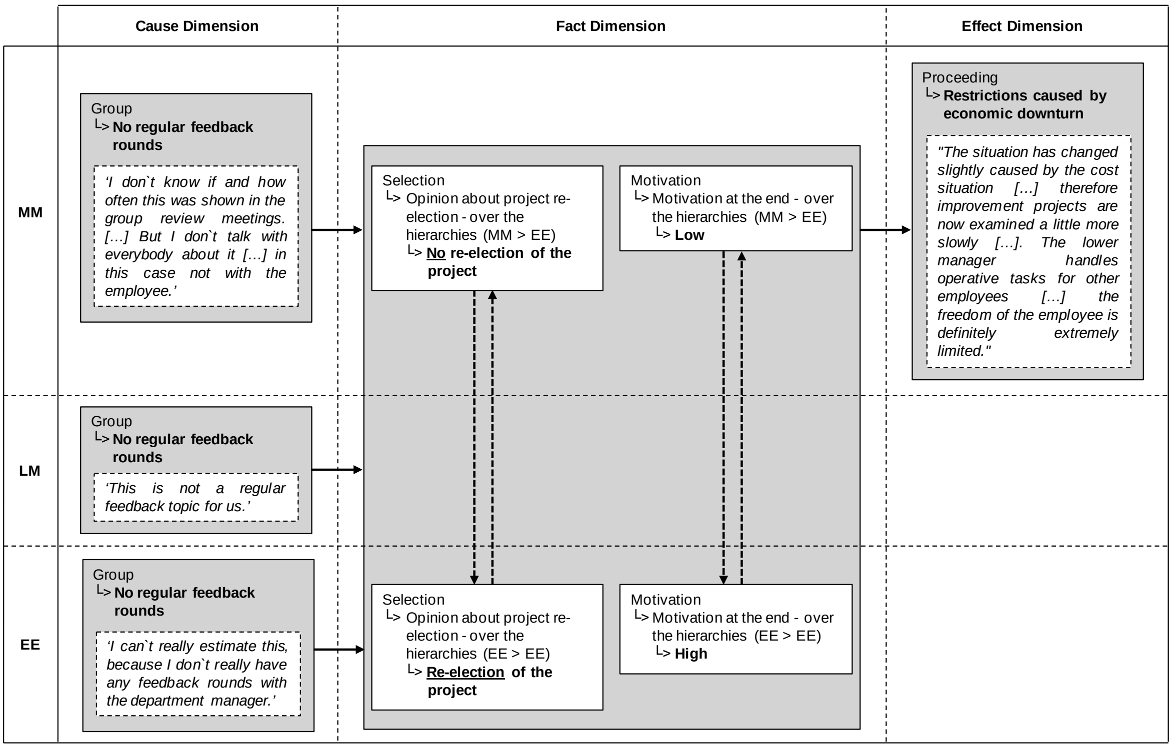


Figure 4.17: Causal chain hypothesis 4 (own illustration)

Due to the sparse communication between the project members, and in particular over the hierarchy (cause dimension), the project evaluations show a broad spectrum. This is displayed by the fact that the MM evaluates the motivation as well as the will to re-elect the project of the EE as negative, while the EE actually evaluates his motivation and will to re-elect at a high level respectively positive (fact dimension). As a consequence the range of the project was limited by the MM (among others, by the restriction of freedom; effect dimension). Consequently a sustainable illustration of the success of the young project is difficult to ensure. This seems remarkable as all project members (MM, LM and EE) share the opinion that it is necessary to ensure a focusing of the project over a longer time to reach any success (Success → Point in time of success realization → Success can only be seen in the long run).

Hypothesis 4: A sufficient information exchange is important to ensure a project's continuation.

<u>Selection enforcement</u>

	TE		LO		QM	
	P1	P2	P1	P2	P1	P2
MM					X	
LM		X			X	
EE					X	

Figure 4.18: Cross case analysis hypothesis 5 (own illustration)

In Project QM-P1 an enforcement to choose the project has been reported (Selection → Reason for selection → Enforcement). Enforcing the project could create a ressistement.

Within the project a scepticism towards the project examination has been present from the beginning (cause dimension). This fact, considered in the context of the enforcement to choose the project (fact dimension) within a top-down selection process has led to the method being abused. The target of this was to justify the current status quo and therefore to fight against any change (effect dimension). The impact of the cause dimension on the effect dimension should be pointed out in particular, supported but not solely caused by the fact dimension. This is displayed in the self-affirmation of the MM: 'for me it was clear at this point [...] that this topic was not the right instrument' as well as the positioning of the project exclusively in the own area (Classification → Focus on own area). Consequently the ressistement developed due to the top-down enforced selection process of the project makes an identification of primary desired improvements not only complicated but nearly impossible.

Hypothesis 5: To avert resentment towards the improvement method, a reflective selection of a project is crucial.

QM-P1:

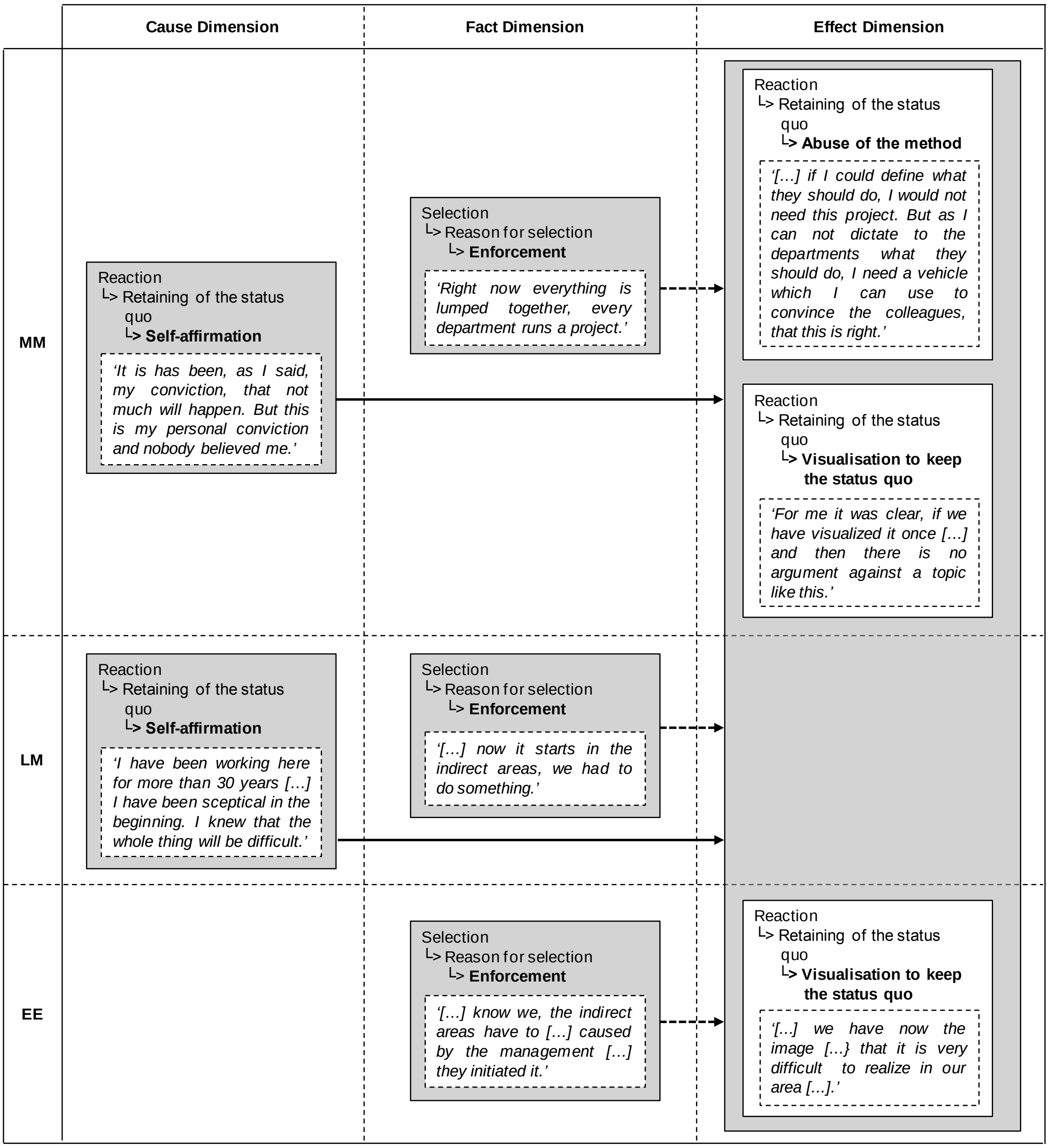


Figure 4.19: Causal chain hypothesis 5 (own illustration)

Freedom

	TE						LO						QM					
	P1			P2			P1			P2			P1			P2		
	MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE
MM	X	X					X			X								X
LM	X	X					X			X							X	
EE	X		X			X	X			X						X	X	X

Figure 4.20: Cross case analysis hypothesis 6 (own illustration)

In project QM-P2 all involved parties pointed out correspondingly the not-total freedom of the employee (Leadership → Freedom – over the hierarchy → Not enough freedom/Partly enough freedom).

QM-P2:

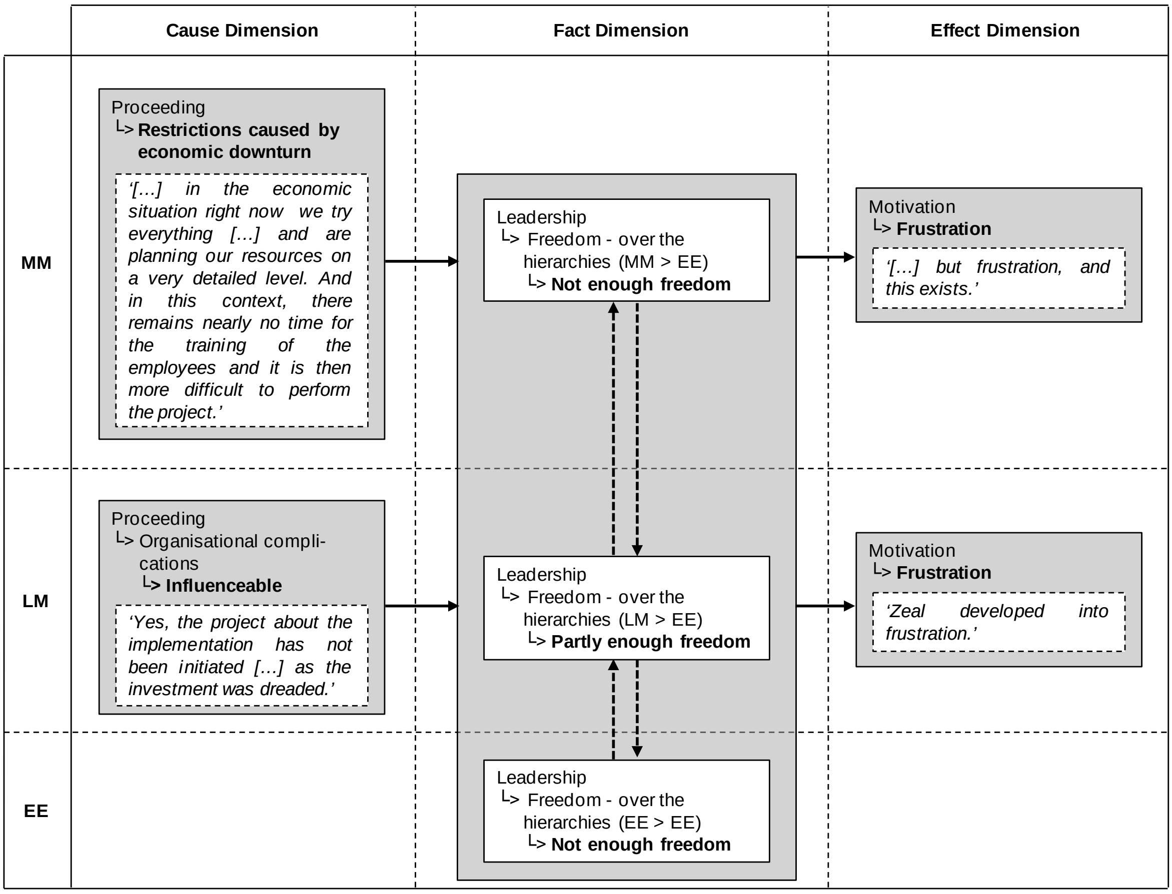


Figure 4.21: Causal chain hypothesis 6 (own illustration)

Caused by the suboptimal conditions and the constraints due to the cyclical restrictions (cause dimension) the freedom of the employees within the project has been restricted (fact dimension). This is displayed in the frustration of the employees recognized by the managers (effect dimension), which can be considered as an obstacle to the identification of further self-induced improvement activities.

Hypothesis 6: Sufficient freedom is of crucial importance to keep improvement activities going.

Reasons for the same effect

Strategic goal deduction

	TE		LO		QM	
	P1	P2	P1	P2	P1	P2
MM	X	X	X	X	X	
LM	X	X	X	X		X
EE	X	X	X	X	X	X

Figure 4.22: Cross case analysis hypothesis 7 (own illustration)

In all cases the selection of the projects has been driven by a deduction process at a department level (Selection → Reason for selection → Derivation at department level); no project has been selected based on a strategic goal deduction process. As it can be assumed that a pre-setting of strategic parameters is necessary to reach any process improvements in indirect areas (Deiwiks et al., 2008), a central breakpoint between the operative level of the process examinations and the respective improvement actions and the ideal goal deduction process for the project selection can be identified.

Caused by the derivation of the projects at a department level (cause dimension) and the focus on own areas (fact dimension), the projects are limited in their impact and time horizon (effect dimension). Considering the insufficient deduction process from superior goals, it seems hard or even impossible to reflect the (limited) reached improvements in a financial matter in superior strategic goals. Therefore ensuring success identification is barely possible.

Hypothesis 7: An embedding in the strategic goal deduction process is important to ensure a large scope for improvement activities.

QM-P1:

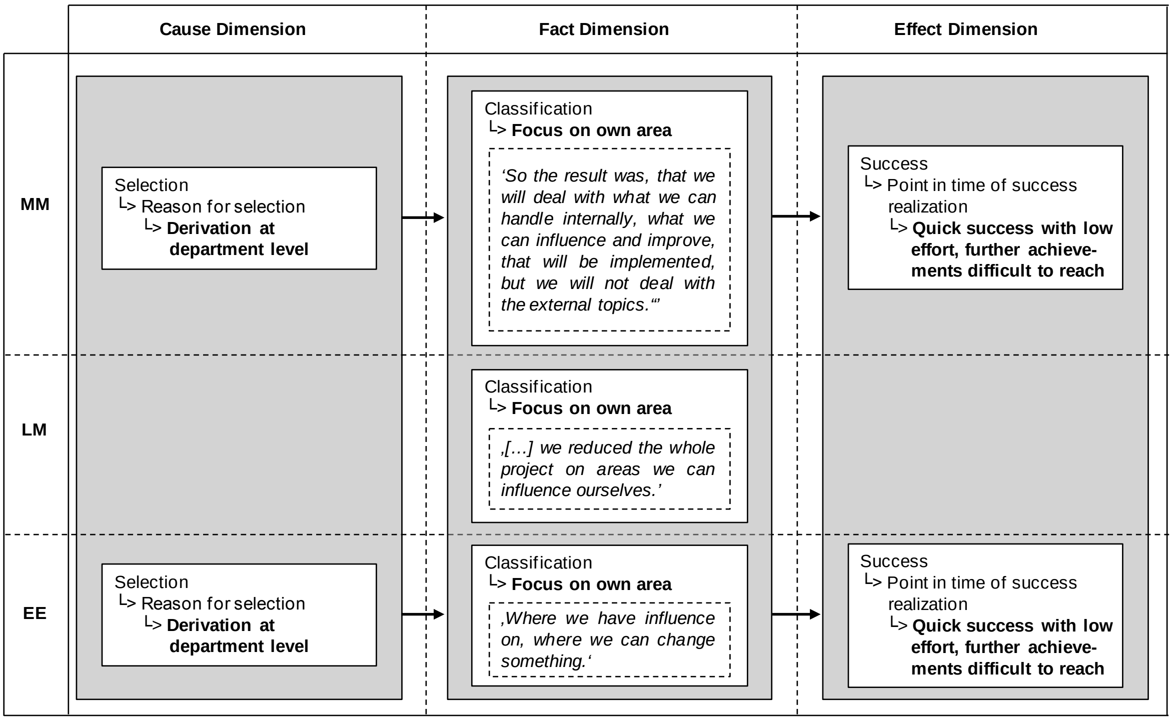


Figure 4.23: Causal chain hypothesis 7 (own illustration)

Same condition, different effect

Success determination

	TE						LO						QM					
	P1			P2			P1			P2			P1			P2		
	MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE	MM	LM	EE
MM				X	X		X	X	X	X	X	X	X		X	X	X	
LM		X	X	X		X	X	X	X	X	X	X	X	X	X			
EM										X	X	X	X	X	X	X	X	X

Figure 4.24: Cross case analysis hypothesis 8 (own illustration)

In the comparison of the success determinations of the experts over the hierarchy within the projects, only project LO-P2 showed a complete consensus regarding the question of how the success 'manifests itself' to the individual and to other project members (multiple naming has been considered as well). In all other projects, the success has been evaluated differently even though the starting point was the same for all of them.

LO-P2:

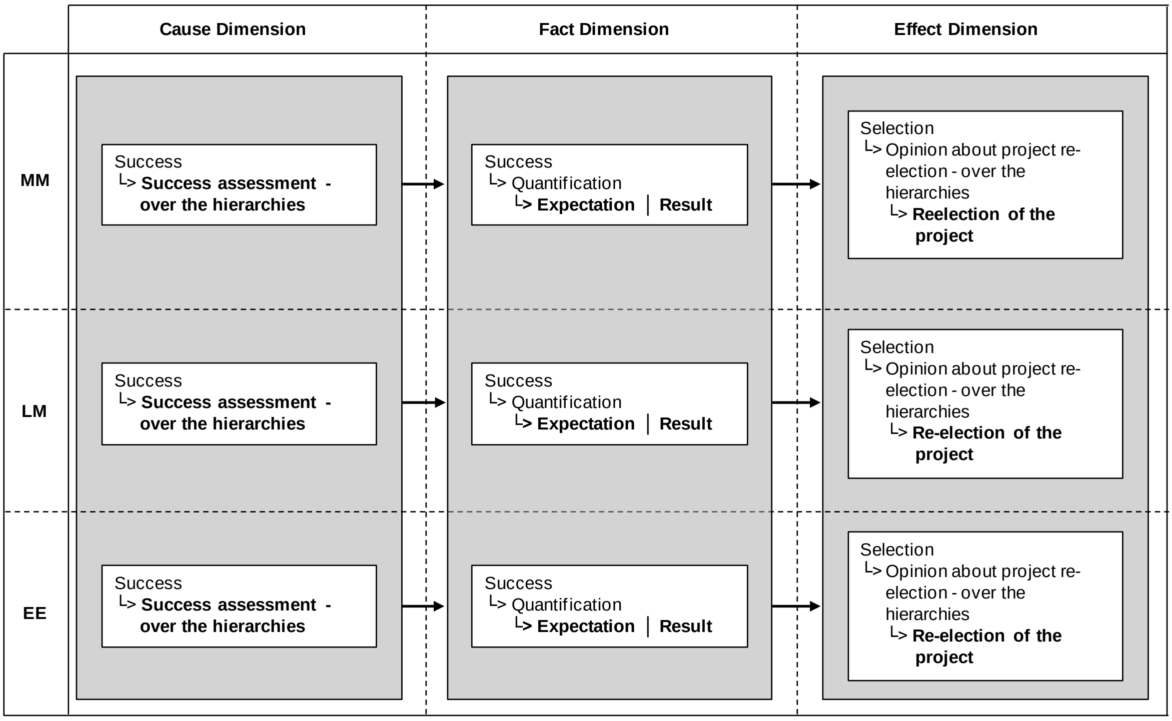


Figure 4.25: Causal chain hypothesis 8 (own illustration)

Considering the fact that the difference between the expectations and the results within LO-P1 have been the largest (fact dimension), the statement of the re-election over the hierarchy (so implicit a positives project evaluation) seems remarkable (effect dimension). Therefore the creation of a common success definition can be considered as being of crucial importance (cause dimension). The exclusive existing consensus in project LO-P2 regarding the re-election of the project (as far as the evaluations could have been collected) can be considered as an elementary contribution to ensure sustainable success identification.

Hypothesis 8: A common understanding of success is crucial to reach any success.

4.7.6 Expert Overview

Expert	Hierarchical level	Function	Previous function
1	Senior Management	Commercial coordinator	Manager of public communication as well as internal improvement department
2	LM	Manager of public communication as well as internal improvement department	Process consultant for indirect processes
3	Senior Management	Production manager	Manager of a production supporting indirect department
4	LM	Manager in the accounting department	Process consultant for indirect processes
5	MM	Manager of a production supporting indirect department	Manager of a production supporting indirect department
6	MM	Head of the management accounting department	Manager in the accounting department

Table 4.3: Expert overview (own illustration)

4.7.7 Evaluation Scale of Tightened Hypotheses

	no agreement at all	negligible agreement	partial agreement	full agreement
1 Transparency Only transparency does not generate any monetary benefit.				
2 Rationalization to prevent the effect of diffusion If generated rationalization potentials are not pointet out, the saved time will be used otherway.				
3 Collective target tracking You have to pull together, to be succesfull.				
4 Insufficient information exchange To know whats going on, you have to talk to each other.				
5 Selection enforcement If projects are enforced, failing is preprogrammed.				
6 Freedom To not prevent improvement activities, enough freedom has to be ensured.				
7 Strategic goal deduction Without a strategic goal deduction, improvements are limited in their scope.				
8 Success determination To reach any success, you need to have the same understanding.				

Figure 4.26: Evaluation scale (own illustration)

4.7.8 Hypotheses Discussion

Hypothesis	Expert	
1. Transparency	5	*'What gets measured gets controlled, so in the moment when you write down the numbers on the board, interesting reactions are provoked.'* *'I didn't take care about anything, I just let them calculate the net time plan, this led to an increase within three months from 40% to 90%, because the employees said, hey, we are actually just standing around.'*
	3	*'So there is a difference from my perspective, there is transparency, which is observable by the employees and can be influenced, and there is the transparency which you are using in the context of this term [...] I also know where the beasts are from.'*
	1	*'This comes with addressing the situation directly. Transparency leads to a direct effect and because of this, there is a direct reaction, which might be monetary.'*
2. Rationalization to prevent the effect of diffusion	5	*'This actually can be useful, to get this over with other topics.'*
3. Collective target tracking	5	*'Not only this, you also have to pull together in the same direction.'* *'It depends a little bit how global-galactic the strand is formulated.'*
	1	*'We don't have in the company, when I´m looking from the top, the same targets and we even have contrary targets; we don`t always have to pull together, nevertheless, we have to march in the same direction and handle the opposing targets.'*
4. Insufficient information exchange	3	*'There are topics [...] he has ordered them […] where nobody knows anything about them, he has worked on this for years, we know that […] and nobody knows hardly anything about it.'*
6. Freedom	3	*'But to confront an already overloaded employee with even more, which would result in more work, I must say this is condemned to failure.'*
	1	*'No, no, when he can gain freedom from the improvement progress he will do this.'*

Table 4.4: Summarized results of expert discussion (own illustration)

4.7.9 Recommendations Development

Group	No.		**How** to support the appearance of the approved hypotheses.	**Why** these recommendations should work.
Group 1 Expert 1 Expert 2 Expert 3	1	Transparency		
		a	Definition of comprehensible and replicable key figures	Derivation of key figures based on experiences, trainings and established methods
		b	Building awareness of emotional concerns	
	2	Rationalization to prevent the effect of diffusion		
		a	Filling the gap by growth, without increasing the basic capacity	If growth exists, the capacity limit will be capped; controlling the used capacity within the process
		b	Reached freedom is filled up by specific tasks (if the circumstances require, capacity might be removed from the department)	Specifically removing resources from processes
		c	Capacities are summarized on one head count	Demanding an employee listing
Group 2 Expert 4 Expert 5 Expert 6	3	Collective target tracking		
		a	Development of perspectives for project members, considering the possible self-rationalization effect	Reduction of fears about self-rationalization
		b	Creation of a win-win situation	Increase of the motivation of the participants
		c	Installation of an incentive system	
		d	Consequent target cross-setting in the beginning	Creation of a shared view on the target
	4	Insufficient information exchange		
		a	Team-building activities	Creation of culture of discussion, communal spirit
		b	Installation of regular meetings	Creation of freedom, definition of obligations
		c	Encourage the attendees to participate	Self-explaining
	6	Freedom		
		a	Effort planning beforehand	Determination of the required freedom
		b	Alignment with existing capacity	Clarification, if freedom does exist
		c	Definition of time frames	Predictability and security of the employee
		d	Prioritization	If capacities are missing

Table 4.5: Developed recommendations by experts (own illustration)

4.7.10 Efficiency and Realization Effort

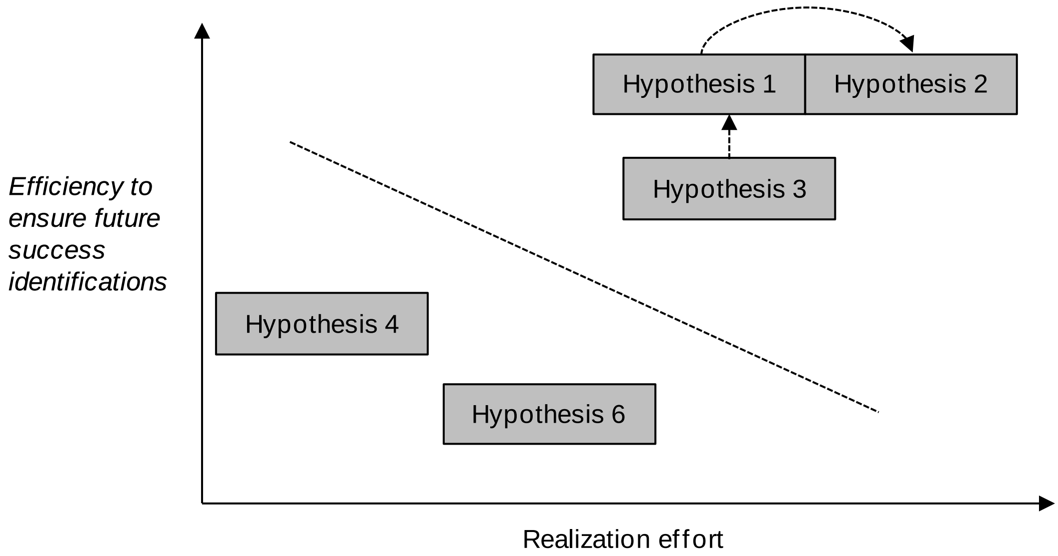


Figure 4.27: Ratio of efficiency and realization effort (own illustration)

5 Summary of the Results and Implications for Practice

The main insights of this thesis are briefly summarized in the following. Overall, the findings of this work empower organizations to address two common and important problems in the PDCA circle of continuous improvement activities in indirect areas, namely the appropriate planning of improvement activities and the checking for the results. Furthermore, it should be pointed out that the research results are not only of interest for applications in indirect areas, but are of interest in all areas where improvement decisions must be taken under conditions of uncertainty.

A common assumption in research on decision-making is that (external) benchmarking figures are available for the purpose of determining the potential for improvement. However, such figures are often not available in business practice. In order to facilitate the derivation of meaningful and profound targets in the absence of benchmarking figures, two new methods have been developed. The TSIP method in paper 1 (Chapter 2) therefore incorporates an ANP analysis to determine the value contribution of each indirect process of an organization and its potential for improvement, as well as ABM to determine the corresponding costs to perform these processes. The data are used within a performance management approach, based on an efficiency analysis, which enables the derivation of individual improvement requirements for each (indirect) process to ensure the achievement of superior organizational targets.

Following the idea of using the internal value of indirect processes as a basis for efficiency analysis, the method developed in paper 2 (Chapter 3) goes a step further, as it allows decision makers to also consider the aspect of fairness when allocating improvement targets among the (indirect) processes of an organization. For this purpose, an MILP formulation of a social welfare function was adapted, incorporating the results of a preceding DEA analysis and the consideration of the strain level of each process to reach improvement. The methods developed will probably not only receive attention in academic discussions, but will also be recognized by practitioners. This has already been demonstrated within the CRA of paper 1: The cooperating organization is already using the TSIP method as an integral part of its yearly rolling budgeting process, and intends to roll out the method even further among other business units. The results of the research presented in papers 1 and 2 can be summarized as:

Main result 1: *Quantitatively derived and fairly allocated improvement targets can be set for each indirect process of an organization based on an efficiency analysis without the need for external benchmarking figures.*

The inability to pinpoint the sustainable success of improvement activities in indirect processes is reported as a common challenge in business practice. For the purpose of facilitating the checking step of the PDCA circle of improvement activities in indirect processes, the research insights of paper 3 (Chapter 4) are of interest. The multi-step case analysis is used to identify circumstances that hinder the identification of success. Recommendations are derived that will help practitioners to counter such limiting factors in business practice. Furthermore, the recommendations derived have the potential to not only facilitate the identification of success, but also the primary achievement of improvements, as some of the circumstances are congruent with the general success factors of improvement activities. In this regard, the second result can be summarized as:

Main result 2: *Factors are identified, covering aspects such as transparency, diffusion, target tracking, information exchange, and individual freedom, which potentially hinder the pinpointing of the success of improvement activities in indirect areas.*

6 Discussion and Future Research

Despite the contribution that this research makes to the field of continuous improvement management in indirect areas, limitations exist which shall be reflected in the following. In addition, potential fields of future research will be identified.

From a methodological perspective the determination of the service contribution level of each indirect process within an organization, which represents an important element of the planning methods introduced in papers 1 and 2 (Chapters 2 and 3), is of interest for further investigations. The suggested use of ANP for that aim has demonstrated great capabilities; however, in view of the requirement of being economically manageable, formulated at the beginning of the thesis, the possibly high degrees of effort to examine ANP in practice have to be acknowledged. Therefore it would be interesting to evaluate the usability of alternative priority determining proceedings in future research, such as fuzzy ANP analysis.

Another topic for future research would be the validation of the factors determined within the qualitative research setting in paper 3 (Chapter 4) that hinder a pinpointing of the success of improvement activities in indirect areas: Although a rigorous research proceeding was followed, qualitative data mostly allows different interpretations, especially in complex systems in which a variety of influence factors exist (as it is the case in indirect processes). This can be done either via longitudinal studies or by quantitative empirical studies. Nevertheless, taking into account the novelty of the research field, and the low level of comparability of indirect processes among different organizations, the chosen research strategy has demonstrated its ability to generate valuable and novel research insights.

A PDCA circle consists of four steps. While the focus in this research was on planning improvements and checking for their results, it will be of interest to ensure a comprehensive PDCA strategy in indirect areas in the future, to also analyze the two remaining aspects as well – doing and acting. With regard to rolling out improvement initiatives, the potential risk of focusing on the symptoms rather than on the sources of inefficiencies always exists, especially if cost reductions are intended (Kajüter, 2005). Furthermore it should be pointed out that an organization is a social system, and the success of any measure will always depend on human behavior (whether of managers or of other staff). To date, there is no complete, integrated theory to deduce an optimal principle of their behavior (Saaty & Vargas, 2012). Therefore, an ideal way of integrating associates within the improvement target derivation process in order to address the real sources of inefficiencies will be of interest for future research in the context of indirect processes, as they are typically very labor intensive. In addition, from an organizational theory perspective, it should be noted that functional, hierarchical and bureaucratic organizational forms can still be found in many organizations (Hess & Schuller, 2005; Wilhelm, 2007; Wagner & Käfer, 2008). These forms do not facilitate continuous improvement to the fullest extent (Delbridge & Barton, 2002). Consequently, the likelihood of the success of improvement activities in indirect areas will depend on how these burdens are addressed. One key to success to facilitate the doing and acting within a comprehensive PDCA improvement strategy might be process ownership, aiming for clear management responsibilities and an enhancement of appropriate reporting structures (Mayer & Brenner, 2009; Picot & Liebert, 2011).

7 Conclusion

Continuous improvement activities in indirect processes have recently gained increasing interest among many organizations. Considering that methods and trends are sometimes applied without critical reflection among organizations due to adaption pressure within elite networks, as assumed by DiMaggio and Powell (1993), some might claim that this might just be another fad (Berger, 1997). Opposing to this potential objection is the fact that continuous improvement of direct processes is already well established and in the light of fierce competition organizations need to find ways to optimize their complete value chain. Therefore, the focus on indirect processes should be considered as an ‘ongoing trend’, making the question of how improvement programs in indirect areas can ideally be managed highly relevant (Schuh et al., 2012). To date, there exists no ‘gold standard’ for planning improvement activities in indirect areas, for example within budgeting processes, and to pinpoint the success of such activities in the aftermath. The methods and research insights of this thesis present a contribution to addressing these challenges. Moreover, the results might also be of interest for improvements in direct processes driven by high complexity levels, potentially causing the same difficulties to detect cause-effect correlations as in indirect processes. Besides contributing to the body of knowledge on continuous improvement in the academic discussion, the methods and insights are also of high value for practitioners as demonstrated in the case studies that were examined.

Notations and Symbols

Chapter 2

Sets

P	set of processes indexed by p
A_p	set of activities a belonging to process p

Parameters

AC_a	allowable costs of activity a
c_a	cost of activity a
d_p	driver of process p
DC_a	drifting cost of activity a
G	reduction goal
lu_a	minimum distance of activity a
p_a	target cost reduction considering the capacity of improvement of activity a
pAC_a	allowable cost of activity a considering capacity
s	subsidizing factor
s_a	subsidized target cost reduction of activity a
sAC_a	subsidized allowable cost of activity a
t_a	target cost reduction of activity a
x_a	value contribution of activity a
y_a	capacity to be improved of activity a
z_a	normalized capacity to be improved of activity a
$\bar{z}$	mean of the normalized capacities
q, λ_a, δ_a, α_a, β_a	auxiliary parameters

Chapter 3

Sets

A_p	set of activities a belonging to process *p*
I	set of inputs indexed by *i*
O	set of outputs indexed by *o*
P	set of processes indexed by *p*

Parameters

b_{ad}	y-intercept of the utility function of activity *a* in interval *d*
c_{ia}	unit costs of input *i* for activity *a*
D	number of intervals *d*
Δ	threshold for switching from efficiency approach to equity approach
G	reduction goal
lb_{ad}	lower bound of the d^{th} interval of activity *a*
M	large number
m_{ad}	slope of the utility function of activity *a* in interval *d*
n	number of activities
R_a	maximum possible cost reduction of activity *a*
ub_{ad}	upper bound of the d^{th} interval of activity *a*
x_{ia}	amount of input *i* consumed by activity *a*
y_{oa}	amount of output *o* generated by activity *a*

Decision variables

λ_{ja}	multiplier variable on activity *j* corresponding to activity *a*
r_a	cost reduction for activity *a*
s_a	strain level of activity *a*
u_a	utility level of activity *a*
w	lowest utility level amongst all activities
$\hat{x}_{ia}$	minimum amount of input *i* to be consumed by activity *a*
z	overall utility contribution amongst all activities

Auxiliary decision variables

$$k^{-}_{ad} = \begin{cases} 1 \text{ if } & r_a \geq lb_{ad} \\ 0 & \text{otherwise} \end{cases}$$

$$k^{+}_{ad} = \begin{cases} 1 \text{ if } & r_a \leq ub_{ad} \\ 0 & \text{otherwise} \end{cases}$$

$$\varphi_{ad} = \begin{cases} 1 \text{ if } & lb_{ad} \leq r_a \leq ub_{ad} \\ 0 & \text{otherwise} \end{cases}$$

δ_a; v_a	decision variables to specify the objective function contribution of activity *a*

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