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Selecting business improvement methods
towards a technique for consultants to support the selection of methods in an
improvement project

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Selecting Business Improvement Methods
Towards a technique for consultants to support the selection of methods in an improvement project

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In partial fulfillment of the requirements for the degree of
Master of Science in Operations Management and Logistics

Supervisors:

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- dr. ir. P.M.E. (Pieter) Van Gorp (TU/e – IEIS – IS)
- dr. M. (Manish) Kumar (Infosys – Infosys Labs)

31st August, 2011
“One of the most important abilities you can develop is the ability to ‘learn how to learn’ – to constantly absorb, and teach yourself, new ways of doing old things, or new ways of doing new things. To learn how to learn, you have to love learning – or you have to at least enjoy it – because so much learning is about being motivated to teach yourself. And while it seems that some people are just born with that motivation, many others can develop it or have it implanted with the right teacher (or parent)”.  
Friedman – 2007
Abstract

To remain a competitive and sustainable company in today’s turbulent and dynamic business environment, organizations are required to constantly rethink their business functions and processes. In order to keep up with the pace of their competitors and exceed the expectations of their customers, organizations start improvement projects. An improvement project concerns improving functions or processes in a company for a finite time span.

There is a large variety of Business Improvement (BI) methods to apply in an improvement project. Their various possible permutations can make it difficult for a company to choose the best approach for its project-related and organizational characteristics. Total Quality Management, Six Sigma, Lean, Business Process Reengineering and Business Process Management are among the most popular BI methods which can guide and support an organization’s improvement project (Wieleman, 2011) and have been selected as the focus in this study. There is little research providing assistance and guidance to consultants on how to select BI methods to apply in an improvement project. Most literature on BI and Quality Management has its focus on describing the concept, methodology and tools of each improvement approach, often also providing empirical evidence on strengths, weaknesses and critical success factors (Thawesaengskulthai, 2006). However, most of the literature describes only one method in their analysis. There is little comparative analysis available to provide support to the decision making process of selection of BI methods. Moreover, the validity of the literature on BI and Quality Management can be questioned, as most of these researchers seem to favor the use of one specific BI method. Researchers claim a specific BI method to be a panacea for all organizational problems and this particular method can be applied to any type of organization (‘one-size fits all’) (Mohammad, 2010). In reality, there is also the recognition that there are different criteria influencing the selection of BI methods as some methods are more effective under certain conditions, contexts and situations (Ricondo and Viles, 2005). These statements have urged the rise of a new research field on how consultants can best select BI methods which can be applied to a specific improvement project within a company in order to maximize the achieved effectiveness. Therefore the main research question has been formulated as follows:

How can the selection of BI methods to be applied in an improvement project be rationalized, supported and justified?

Prior to this research, a literature study was conducted in which it became evident that many consulting firms need guidance on how to select the most suitable BI method to apply at an improvement project. When an organization starts a new improvement project, they contract a consulting firm to support them in the selection process concerning BI methods. Decision makers from both the organization and consulting firm, however, seem biased in the selection process with a preference for specific BI methods regardless of the context. Through these biases consulting firms will not be able to exploit the potential of other BI methods which they have not considered in their selection process. This will ultimately lead
to consultants suggesting BI methods that do not act upon the true needs of the organizations considered to change.

**Research Design**

The research was carried out in three phases. The first phase was the *literature study* in order to establish a conceptual background regarding the selection of BI methods. Phase Two was a *theory building* process, where a decision support technique (DST) was designed to help consultants in deciding the business improvement strategy for a specific improvement project. This part of the research has been carried out in a consulting environment at *Infosys Technologies Limited* in Bangalore (India). Different decision criteria for the selection of BI methods were identified and validated. In-depth interviews with fifteen experienced consultants provided insights into BI practices from which the DST was designed. Next to that, we used this phase to build a selection framework through which we were able to position the use of the DST in the selection process of BI methods (Chapter 4). Then in Phase Three (*theory testing*), the proposed DST was validated, verified and refined through two evaluation sessions with senior consultants. The first session was conducted with Indian consultants from Infosys after which the DST was redesigned for the second session with Dutch consultants from *IBM* and *Deloitte*. We also used these evaluations to validate, verify and refine the selection framework. After these evaluation sessions the designs of the DST and selection framework were finalized.

**Results**

The selection framework has been based on existing academic publications from Thawesaengskulthai (2006) and Mohammad (2010), complemented with experience gained from in-depth interviews and a proprietary framework of Infosys (which could not be disclosed concerning IP rights). The designed framework promotes rational decision-making and assists consultants to frame their selection process, compile useful information and reach a consensus decision with justification by the DST. Its main goal is to position the use of the DST throughout the selection process of BI methods in an improvement project.

The decision support technique uses three different phases to come to a supporting selection of most suitable BI methods. These phases have been developed by the combination of decision models available in the academic literature and the interviews with consultants from Infosys. The first phase is *elimination-based*, based upon the organizational characteristics of a company BI methods can be eliminated from the selection. The second phase consists of a *scoring model* where project-related requirements and the worldwide popularity of BI methods will provide a score and ranking of the alternative BI methods. This allows consultants to integrate concepts and techniques from different BI methods to increase the possible effectiveness of the improvement project. The third phase consists of a *sensitivity analysis*, where consultants can assess the robustness of the ranking calculated by the scoring model, both quantitatively and visually. This phase has been introduced to increase the confidence of consultants in the accuracy of the scores calculated by the DST.

In Chapter 9 we sum up several directions for future research. We hope that this work can be continued by both academics and practitioners as it has shown to have great potential in the consulting industry.
Preface

This research project was conducted within the Information Systems group of the department Industrial Engineering & Innovation Sciences (IEIS) at Eindhoven University of Technology (TU/e). It was supervised by dr.ir. H.A. (Hajo) Reijers, who is an Associate Professor in the Information Systems group and leader of the Business Process Management (BPM) research cluster within this group. The second supervisor of this project was dr. ir. P.M.E. (Pieter) Van Gorp, who is an Assistant Professor in the Information Systems group and is also part of the BPM research cluster.

The opportunity was given to the student by his supervisors to conduct research in cooperation with Infosys Technologies Limited\(^1\). Infosys Technologies Limited (shorthand notation: Infosys) is a multinational information technology services and consulting services company headquartered in Bangalore, India. Infosys has a global footprint with 64 offices all around the world and is one of the largest IT and consulting companies with 130,820 professionals (including subsidiaries) as on March 31, 2011\(^2\).

For this research project Infosys’ global internship program ‘InStep’\(^3\) has been followed in Infosys Bangalore from February 2011 to May 2011, i.e. the project has been performed partly in India. The research has been performed in the departments Infosys Labs and Infosys Consulting. Dr. M. (Manish) Kumar, who is a Research Associate at Infosys Labs has guided the research as a co-supervisor. Infosys enabled us to research the decision process of the selection of Business Improvement (BI) methods in an environment with a highly practical interface. Throughout designing a framework and a technique support has been given in assisting and justifying design-related problems and challenges. The design of the framework and technique has been evaluated in both India and the Netherlands, by the consulting departments of Infosys, IBM and Deloitte, in chronological order. This has provided us a broad perspective on required redesigns and future work needed in order to apply the technique in the consulting industry. At the time of writing, we can already mention that the designed framework has been applied in the training program of junior consultants at Infosys Consulting.

The deliverables of this research are the following:

- A Master thesis text (this document), documenting the project’s design process, considerations, decisions and results
- A decision support technique (DST) that will allow consultants to make a selection between BI methods based upon the organizational characteristics of a company and the company’s improvement project characteristics

\(^1\) http://www.infosys.com
\(^2\) http://www.infosys.com/about/what-we-do/pages/index.aspx
\(^3\) http://www.infosys.com/instepweb/internship/
The last six months have been one of my greatest adventures in life. So many people and organizations have contributed to the completion of this project. In the first place, my great thanks go out to my mentor Hajo Reijers for starting this project. He gave me the opportunity to spend three months of my research project at Infosys in India (Bangalore) in an inspiring environment. Manish Kumar was my project mentor at Infosys and stood by my side to help me with any problems, project-related but also personally. He opened my eyes to explore the beautiful things India, and Infosys in particular, have to offer. Especially, I would like to thank Vivek and the other consultants from Infosys that made time to let me discover the great world of consulting. Trupthi Narayan and Ankit Goel, thank you for your support, your explanations on the cultural differences with India and the motivating coffee breaks. The following paragraph gives a brief explanation of what I experienced at Infosys in Bangalore.

“The Infosys campus is reached by a potholed road, with sacred cows, horse-drawn carts, and motorized rickshaws. Once you enter the gates of Infosys, though, you are in a different world. A massive resort-size swimming pool nestles amid boulders and manicured lawns, adjacent to a huge putting green. There are multiple restaurants and a fabulous health club. Glass-and-steel buildings seem to sprout up like weeds each week” (Friedman, 2007). At 8.45 AM, I sometimes stood at the main gate of Infosys to see the thousands of educated employees flooding into Infosys grounds. These people had such a motivation and were so eager to work, that it motivated me to give everything I had during this research.

Hajo, thanks again for your great enthusiasm and positive criticism which stimulated me to get more out of myself and this research. Your experience in both the academic world and the consulting industry made me see things from a different perspective. Pieter van Gorp, as a second supervisor, you provided me with good feedback on intermediate reports that I wrote. Stefan Heusinkveld (Radboud University Nijmegen), thank you for sharing your knowledge on management fashions and research on the popularity of BI methods. Great thanks to the consultants of IBM and Deloitte for participating in the evaluation sessions.

Last, but most definitely not least, I would like to express my sincere gratitude to my family and friends who stood by me through the past five years of university and have supported me in every possible way. My greatest respect and thanks go to my parents for their great encouragement in pursuing my dreams and always standing by my side.

Bart Wieleman
August 2011
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1. Introduction to the research study

In today’s business, we can see an increase in the complexity of products and processes. These trends place unprecedented challenges and opportunities on the sustainable development of organizations. Any organization is therefore required to regularly review its activities and processes to deal with the increasingly competitive and rapidly changing world market (Tiwari et al., 2008). One important way in which competitive performance may be achieved and sustained is through improvement projects. This strategy can be used to obtain lower costs and differentiate products and services from competitors. The organizational desire to become a world-class organization drives the application of Business Improvement (BI) methods to improvement projects.

BI has become an imperative for businesses seeking competitive advantage. Yet it is disturbing how few organizations make lasting and successful use of business improvement methods such as Total Quality Management (TQM), Six Sigma, Lean, Business Process Reengineering (BPR) and Business Process Management (BPM) (Bain and Company, 2005). Consulting firms can be hired by a business who wants to improve a specific business function, business process or explore new emerging markets. These consulting firms will arrive with their client with the improvement methods and tools available in their toolbox. From this toolbox they will choose which BI method(s) are most applicable to a specific business problem. None of these methods are a total answer to any organization’s problem or ambitions, but some methods are more effective to certain organizational and project-related characteristics. Therefore, an important question is:

“On which factors are the selection of BI methods actually based on and why are some improvement methods more applicable to a certain improvement project than to others?”

Despite the demonstrated benefits of BI methods, some improvement projects end in failure. Partly this is because the success of any or all of these methods seem to be very much context dependent (Slack and Lewis, 2010). If a company selects a BI method which does not match to their organizational characteristics, project characteristics or stakeholder’s background, it can lead to a worsening effect of the current business performance (Garfamy, 2011). Besides that, companies have found it extremely difficult to sustain even initially successful process improvement projects. Even more puzzling, initially successful improvement projects sometimes worsen business performance, triggering layoffs, low morale, and the collapse of commitment over the long run (Keating et al., 1999). This phenomenon is also known as the ‘Improvement paradox’.

Consulting firms need a rational system for selecting, applying and integrating the tools appropriate for their client’s improvement projects. “A BI method will improve results only to the extent that it helps discover unmet customer needs, helps build distinctive capabilities and helps exploit the vulnerabilities of competitors – or a combination of all three” (Rigby and Bilodeau, 2005). There are a number of shortcomings in the process of a BI method selection (Adesola and Baines, 2005). Among them, there is a need for an appropriate technique to justify, rationalize and support the selection of one BI method over another by practitioners (Mohammad, 2010). The number of frameworks that are available and
specifically targeted to the selection of BI methods is less than a dozen (Sarkis and Talluri, 2002). The main goal of this research is to develop a technique to support the decision making process in selecting BI methods. As a secondary goal, a guiding selection framework will be designed to describe the selection process of BI methods and position the application of the technique throughout this process.

1.1. Problem Statement

In this chapter the problem statement will be formulated from which the unit of analysis for this thesis and the scope of this research will be determined. The goal of this project is twofold. At the academic level, the project aims at contributing to the scientific knowledge on the application of BI methods and in particular enhancing justification, rationalization and support of the selection of BI methods to apply at an improvement project. The practical goal of the project is to design a decision supporting technique that can improve rationality, support and justification on the selection of BI methods to apply at an improvement project. An improvement project concerns improving functions or processes in a company for a finite time span. In an improvement project objectives are composed which should be accomplished within the time span for the project to be successful. A consulting firm can be hired by a company with an improvement project to help with the selection and adoption of one or more BI methods to an improvement project.

The problem statement and unit of analysis have been formulated as follows:

*The current state of both academic and practical knowledge does not satisfactorily rationalize, support and justify how BI methods should be selected to apply in an improvement project.*

*The unit of analysis for this research will be the selection of one or more BI methods for their application on an improvement project at an organization by practitioners.*

1.2. Research Scope

The scope and focus of this research are as follows:

- The design of the technique to support the decision making will be mainly focused on Total Quality Management, Six Sigma, Lean, Business Process Reengineering and Business Process Management. Nevertheless, we will make an extendible design which should allow other BI methods to be taken into consideration in the selection. This will also provide the opportunity for consulting firms to take their proprietary methods into consideration.
- The technique will be designed in India and the Netherlands, but it is targeted at the world-wide consulting industry. This research does not attempt to design a country-specific decision supporting technique, but approaches this as a universal problem.
- The technique should promote a rational decision making process for practitioners when selecting a BI method. We acknowledge that this process is influenced by irrational factors, which have been looked into from an academic and practical perspective. Nevertheless, we believe that by viewing this problem from a rational stand point the effectiveness of a BI method within an improvement project can be increased.
This project will be design-oriented, meaning that it is aimed at solving or alleviating the unsatisfactory state of affairs that constitutes the business problem. Drawing upon the unit of analysis, problem statement and research scope, the main research question of this project is formulated as follows:

*How can the selection of BI methods to be applied in an improvement project be rationalized, supported and justified?*

From this background and supported by a literature review, which will be summarized in the next chapter, the following research questions have been formulated. These will all be answered in Chapter 9.

- What influential factors are currently analyzed by consultants to determine the best fitting BI method for a specific improvement project?
- How large is the influence of irrational factors on the decision making process of practitioners concerning the selection of BI methods?
- Given the irrational influence on the decision making process, is it still possible and valuable to develop a rationalizing decision making technique?
- What influential rational factors should be captured in a decision support technique to be able to make a selection of suitable BI methods in a specific improvement project?
- How can a framework be designed to explain the selection process of BI methods and position the use of a decision support technique in this process?
- How can a decision support technique be designed which should rationalize, support and justify the decision making process in the selection of BI methods?

### 1.3. Structure of the thesis

The remainder of this report is structured as follows. In Chapter 2 we will compare the BI methods and provide background on decision making models. This chapter is based on a literature study which has been conducted prior to this project (Wieleman, 2011). Chapter 3 describes the research design and explains the chosen research approach. Chapter 4 defines and describes our selection framework which can be used to support and position the decision making process in the selection of BI methods. Chapter 5 describes the method of data collection conducted at Infosys in India. Thereafter, the data will be analyzed in Chapter 6. This chapter reports on the results of a detailed interview process, where we could extract the most influential criteria and other characteristics in the decision making process. Then Chapter 7 describes one of the most important parts of our research regarding the design of a Decision Support Technique (DST) that will aim in supporting, justifying and rationalizing the selection of BI methods in an improvement project. Chapter 8 provides us with more insights how the selection framework and DST were redesigned based upon two extensive evaluation sessions with Indian consultants from Infosys and Dutch consultants from IBM and Deloitte. We conclude our work in Chapter 9 by discussing the outcome of the research and the contribution to the existing knowledge within this research field. The limitations of the research are indicated and some suggestions for future research are provided. A glossary is provided in Appendix A.
Phase 1. Literature Review
In this phase, the main outcomes of the literature review are elaborated upon and a conceptual background is build regarding the selection of BI methods to apply on an improvement project.

1. Literature Review
In this chapter, the relevant literature is reviewed and provides background which underpins this research. The BI methods selected for this research: Total Quality Management (TQM), Six Sigma, Lean, Business Process Reengineering (BPR) and Business Process Management (BPM) will be compared according to various characteristics. Through the literature review (Wieleman, 2011) these BI methods have been selected to be the most popular and well-known methods in the field of Business Improvement. However, this research will use a design which allows other BI methods to be applied to the decision making process. Moreover, this chapter will describe the theory of decision making, management fads and decision making models, as well as with the influential factors in the decision making process.

2.1. A Comparison of BI methods
In this chapter the main concepts of the BI methods will be compared (Table 1). A detailed comparison will be given of the BI methods to examine their distinctive and overlapping characteristics.

<table>
<thead>
<tr>
<th>Scope</th>
<th>TQM</th>
<th>Six Sigma</th>
<th>Lean</th>
<th>BPR</th>
<th>BPM</th>
</tr>
</thead>
</table>

| Main objective | Channeling the organization’s energy toward the customer (internal & external) | Zero defects | Reduction of waste | Force radical organizational change | The design, enactment, management, and analysis of operational business processes |
| Action | Employee empowerment, Identify customer needs and expectations, Identify quality standards | Preventing Quality Failure | Eliminate non-value adding activities | Radically redesign of business processes, Discard ‘as-is’ process | Use of best practices to redesign processes |
| Approach | Bottom-up | Bottom-up | Bottom-up | Top down | Bottom-up |
| CI culture | ✓ | ✓ | x | x | x |
| Nature of improvement | Incremental | Breakthrough | Incremental | Breakthrough | Incremental |
| Examples of Tools | Ishikawa diagram, Pareto analysis | Failure modes and effects analysis, Design of Experiments | Inventory control, Just-in-time, value mapping | Workflow modeling, simulation techniques, force field analysis | Workflow Management Systems, Redesign heuristics |

Table 1. Comparison of BI methods
Each BI method has a distinct concept, aim, methodology, tools and other specific elements, although there is some overlap (Mohammad, 2010). Each of the methods and their characteristics will be explained in the remainder of this chapter.

2.1.1. Scope
The scopes of the BI methods are comparable to each other. TQM, Six Sigma, Lean, BPR and BPM are methods which are constantly focused on improving the business process of a company. The concept of a business process has been defined by Davenport and Short (1990) as “a set of logically related tasks performed to achieve a defined business outcome”. Each BI method views a business problem from a process-oriented view.

2.1.2. Main objective and Action
The objectives and actions of the BI methods differ from each other, each of them will be explained together in this paragraph as these factors are highly related. TQM emphasizes the improvement of processes for both internal and external customers. Internal customers include one’s fellow workers, while external customers include not only those who purchase the good or service but also one’s suppliers and other groups operating in the larger environment that influences the firm’s success (e.g. regulatory bodies). Great attention is paid to identifying customer needs and expectations and then developing products and services that meet or exceed these expectations. The process will be brought under control and standards will be identified, from which the process can be further improved through developing even tighter standards. It advocates a culture in which people are not satisfied with meeting current standards but, rather, push to exceed those standards. TQM emphasizes on employee empowerment as most of the knowledge to improve a given product or service is thought to rest with those directly involved in producing the good or service (Juran, 1989).

The name Six Sigma suggests a quality-oriented goal, which is 3.4 defects per million opportunities (DPMO) where a defect opportunity is a process failure that is critical to the customer. This basically means that zero defects in the product or service is allowed. This goal was far beyond normal quality levels and required very aggressive improvement efforts. However, not all processes should operate at the Six Sigma level. The appropriate level will depend on the strategic importance of the process and the cost of the improvement relative to the benefit.

Lean producers identify their value streams and eliminate all non value-added tasks. Value can be defined only by the ultimate customer. Value is distorted by organizations when they add complexity to the product or service of no interest to the customer (Womack and Jones, 1994). Triggered by customer orders, parts or services should be “pulled” to work stations as they are needed by upstream operations. This fundamental principle of just-in-time (JIT) production control eliminates waste of excessive in-process inventories and increases the visibility of both product and process quality problems.

According to Hammer (1990), BPR is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service and speed. BPR does not deal with an aspect of the organization and its operations but it takes a holistic approach to the entire organization and advocates a total change in the way
business is done by the organization. BPR involves a willingness to rethink how work should be done, even to totally discard current practices if that should prove necessary. The way to implement BPR has been a central point of discussion in the literature. Reengineering is different from most other BI methods because it does not focus on ‘as-is’ but on ‘should-be’. Originally, BPR does not seek to alter or fix existing processes. It forces companies to ask whether or not a process is necessary and then seeks to find a better way to do it (Siha and Saad, 2008).

BPM is regarded as a field of designing and controlling business processes. BPM concentrates on modeling the current business process and then redesigning a process that is in some sense superior to the existing one. The control of business processes focuses on decisions that are taken on the real-time, operational and tactical levels of decision making. Best practices (redesign heuristics) have been collected and applied in various areas to support the redesigner of a business process in the redesign and implementation of a process design (Reijers, 2003).

2.1.3. Approach
Although each BI method has a different objective, their approach is fairly similar. TQM, Six Sigma, Lean and BPM focus on the existing system and improve its performance using a bottom-up approach, while radical change by BPR tends to start from the beginning, using top-down methods. BPR establishes organizational change by assessing the current state of the organization and creating a communication campaign for change. The other four methods concentrate on starting the improvement from an operational perspective and empowering employees to apply a BI method.

2.1.4. Continuous Improvement culture
Today, in many organizations, Continuous Improvement (CI) can be employed in a broad context of organizational excellence and business development. A continuous improvement program is “an evolutionary ongoing process which leads to a better way to compete and add value to existing processes and encompasses the entire workforce of the organization” (McAdam et al., 2000). TQM and Six Sigma are both BI methods which can lead to a continuous improvement culture. The other three methods (Lean, BPR and BPM) are not known to be leading to a continuous improvement culture amongst adopters according to the current knowledge in literature. However, this does not mean that these methods cannot be applied to different improvement projects within an organization.

2.1.5. Nature of improvement
The nature of improvements can be divided into two kinds: incremental and breakthrough. Incremental changes are implemented slowly and gradually over time and require little investment to implement. They are generally achieved through changes in and by an organization’s infrastructure (e.g. people, systems, values and behavior), while breakthrough improvements are generally focused on major structural change (e.g. equipment, facilities, sourcing) (Hayes et al., 2005). Based on these two types of improvement, TQM, Lean and BPM lead to incremental improvements while Six Sigma and BPR lead to breakthrough improvements (Thawesaengskulthai, 2006).

2.1.6. Tools
As a last point, the BI methods will be compared with regard to some of the main tools that these methods have to offer. The main purpose and use of these tools will be explained. However, the
selection of one BI method to apply in an improvement project does not mean that the use of tools from other BI methods is prohibited.

TQM can make use of an Ishikawa diagram (or “fishbone” diagram) to identify root causes to a specific problem. Cause-and-effect diagrams can reveal key relationships among variables, and the possible causes provide additional insight into process behavior. There will always be a single “effect” that an organization wishes to improve, control or eliminate. This organization should list as many possible or probable causes without making the diagram too cluttered. A second tool of TQM is the Pareto analysis, this is a quality control tool based on the principle that a large majority of problems (80%) are produced by a few key causes (20%). The causes of whatever is being investigated (e.g. nonconforming items) are listed and percentages assigned to each cause so that the total is 100%. The percentages are then used to construct a diagram that is essentially a bar chart. In essence, we can think of a Pareto chart as an extension of a cause-and-effect diagram in that the causes are not only identified but also listed in order of their frequency of occurrence. It is generally found that there are a “vital few” causes leading to the effect (Juran, 1989).

Six Sigma makes use of several statistical analysis tools with the ultimate goal to ensure a quality improvement. One of the quality tools used by a Six Sigma organization is the failure mode and effects analysis (FMEA) methodology. This process involves gathering a representative from all the stakeholder groups to start with drawing a process map (similar to business process analysis). The process is carefully examined systematically to proactively determine what could possibly happen detrimental to the product/service at each step of the process. Depending on the severity, the possibility of occurrence and the ability to detect the failure, a relative priority number (RPN) is assigned to each activity (Raisinghani, 2005). If the magnitude of the RPN is high, corrective actions must be undertaken to reduce it. A good FMEA can predict and eliminate many sources of problems before they occur. When a process is being developed or has been identified as needing optimization, a technique called design of experiments (DOE) is utilized. When a process is complex, involving several inputs that may have interactions, a DOE is required to explore the relationship of the outputs to the inputs. The DOE technique explores the operational space for all the inputs, producing results that could show non-linearity and interaction between inputs of a process. The output of a well-defined DOE is a mathematical process model that predicts the response of all the output variables for any combinations of the inputs.

Lean uses inventory control for the supervision of supply, storage and accessibility of products/services in order to ensure an adequate supply without excessive oversupply. Ultimately, inventory control systems can be built to manage and locate objects or materials in real time. Just-in-time (JIT) is a production strategy to remove all waste from the manufacturing environment, so that the right quantity of products is produced at exactly the right time (not late or early), with zero inventories, zero lead time and no queues. It is a system where a customer initiates demand, and the demand is then transmitted backward from the final assembly all the way to raw material, thus “pulling” all requirements just when they are required. JIT is a reactive pull system, which is appropriate for environments in which demand can be forecasted and orders are pulled through the production process. Value mapping is a collection of all actions (value-added as well as non-value-added) that are required to bring a product through the
main flows. The ultimate goal of value mapping is to identify all types of waste in the value stream and to take steps to try and eliminate these. Taking the value stream viewpoint means working on the big picture and not individual processes.

BPR makes use of several techniques to force organizational change. Consultants can use structured techniques such as workflow modeling to document the existing processes of an organization. Sometimes, an organization applying BPR wishes to discard the analysis of the current process as BPR involves a willingness to rethink how work should be done (a clean sheet approach). Workflow is a special kind of business processes. The term “workflow” is used to exclusively refer to the control dimension of a business process, i.e., the dependencies among tasks that must be respected during the execution of a business process (Dellarocas and Klein, 2000). A BPR tool that can be used during redesigning a business process is the use of simulation techniques. Once new process alternatives are documented, simulation allows dynamic modeling to assess process design options (van Meel et al., 1995). In simulation, process variables such as cycle time, queuing times, inputs/outputs, and resources may be manipulated to provide quantitative analysis of process design scenarios in real-time. One of the tools that can be used in reconstructing a business process is Force field analysis where forces are identified resisting new process implementation. A number of communication-based “persuasion” techniques have proven effective in supporting change management. This should compensate with the lack of effective human resource techniques to assist change in compensation, career paths, and work-role rotation, as a consequence of a new process design (Davenport, 1993).

BPM makes use of workflow modeling to document and redesign business processes of an organization, similar to BPR. However, BPM can be seen as addressing two shortcoming of BPR. In the first place, BPR focuses on just the design phase in the life cycle of a process, while BPM also concentrates on other issues that a process manager is concerned with such as monitoring and control of a business process (Reijers and Heusinkveld, 2004). BPM extends the use of workflow modeling by making use of Workflow Management Systems (WfMS) to support the definition, execution, registration and control of business processes (Van der Aalst, 1998). In practice, a WfMS takes care of delivering the right piece of work to the right resource at the right time (Reijers, 2003). In handing out work, WfMS’s are able to integrate with other types of information technology, such as databases, document management systems and transaction systems. Similar to BPR, BPM can make use of simulation of a workflow where cases (e.g., new orders) are generated for the model in execution to examine the process behavior. As mentioned earlier, Reijers (2003) gives an overview of redesign heuristics that can be used to improve a workflow. These heuristics are focused on a wide range of redesign opportunities, e.g. optimizing single tasks within a workflow, trying to improve the routing structure and the allocation of resources.

2.1.7. Conclusion
We can conclude that although each BI method has a distinct main objective and action, their scope, approach, continuous improvement culture, nature of improvement show a lot of overlap. Even the tools of a specific BI method have been shown to be applied to other methods (Kettinger et al., 1997). This means that the tools used within BI methods are not applicable to only a single method. Next to that, each method makes use of a methodology to analyze the current process to be improved from different perspectives. TQM uses it to identify root causes to a problem, Six Sigma uses it to examine
detrimental effects to a product, Lean uses it to identify non-value adding activities, BPR uses it as an input for radical redesign and BPM uses it as an input to apply redesign heuristics upon. BPR is the only method that sometimes discards the analysis of the current process. Therefore, randomly selecting a BI method to apply to an improvement project can lead to conflicting objectives between the objectives of an organization’s improvement project and the objective of a BI method. The magnitude of the detrimental effects on the overall effectiveness of an improvement project when a BI method is selected with conflicting objectives will still have to be researched by other academia.

Applying one method to an improvement project does not mean that other BI methods cannot be applied to this improvement project. Combining one method with another, which is expected to be complementary and produce better solutions, dominates the current literature on business improvement. On the other hand, McNeil & Greatbanks (2002) noted that in fact blending too many BI methods together can be confusing and if used at the same time can reduce the overall effectiveness.

Although we have concluded that these BI methods have a great overlap, we can conclude that the main objective and actions of BI methods differ. This causes the perspective from which tools are used to be different. The challenges remains as to how a company chooses the right BI methods for their improvement project which suits their culture, delivers and sustains the desired results and whether their people have the capability to execute and handle the improvement tools.

2.2. Decision Making and Management Fads

Businesses seem to not optimize their decision making to reach a rational assessment between alternatives (Doyle, 1998). In order to look into the influence of rationality of a decision making process, we should have a definition for how reasoning is considered in practice. “Practical reason in the general human capacity for resolving, through reflection, the question of what one is to do” (Wallace, 2008). Practical reasoning takes a distinctively normative question as its starting point. “It typically asks, of a set of alternatives for action none of which has yet been performed, what one ought to do, or what it would be best to do” (Wallace, 2008). This definition clearly reflects to our research in the selection of BI methods. In practical reasoning, decision makers attempt to assess and weigh their reasons for action, the considerations that speak for and against alternative courses of action that are open to them.

Managers and consultants are claimed to be willing groups to look for something new and innovative when they want to improve a part of their business (Gibson et al., 2003). Abrahamson (1996) argues that norms of managerial rationality and progress dictate the enthusiasm with which management greets any new fad. Each BI method has been claimed to be a management fad. Fad behavior can be marked as the abandonment of approaches in favor of new ones that may actually be similar (Abrahamson, 1996). At any given time, practitioners and researchers are likely to agree that older BI methods were deficient, and that their popularity was not justified by performance improvements (Näslund, 2008). Ettorre (1997) discussed five stages in the cycle of management fads: (1) discovery, (2) wild acceptance, (3) digestion, (4) disillusionment, and (5) hard core. During the digestion stage, critics start suggesting that the method may not be ultimate savior it once was believed to be. By the hard core phase, fads evolve into new management practices or are abandoned as failures. In Chapter 7.3.3., we
examine the lifecycles of each of the BI methods. We can conclude from that chapter that Six Sigma, Lean and BPM can be put in the digestion phase (3) and TQM and BPR can be put in the hard core phase.

For decades, there has been a discussion on the adoption of management fads in the research field of BI methods. This ‘irrational’ motivation for the adoption of BI methods by companies has been criticized by researchers (Abrahamson, 1996; Clark, 2004; Näslund, 2008). Staw and Epstein (2000) found that organizations often copy other organizations to gain legitimacy rather than technological or economic advantage. In this way, the adoption is created by organizations which are continually searching for improvement in their operations and strategy. This will ultimately lead to consultants applying BI methods that do not act upon the true needs of the organizations considered to change.

2.3. Decision Making Models

In the field of consulting, decisions often times have a significant impact on the welfare of companies and on the goodwill of a consultancy firm. Rational and irrational decision making play big roles in today’s decision-making processes within a consulting firm. The objective of this research is not to replace decision making of consultants in their selection of BI methods, but rather to improve the quality of decisions by making it more explicit and rational. This chapter will elaborate on available decision making models to describe the fundamental characteristics of supporting decision making.

The concept of rationality is the basis of most formal models of decision making. The idea is that models can be developed that will show the decision maker how decisions should be made in order to be successful. This approach is termed normative, as opposed to descriptive, because the model is suggesting how decision should normally be made.

- Normative – How decisions should be made
- Descriptive – How decision are made

![Figure 1. Rational Decision Making](image)

Normative decision making models assume that a set of relevant alternatives with corresponding outcomes is known. However, we need to be critical to this assumption and accept that in real situations there are usually an infinite number of possible decisions which cannot all be taken into account. There is a plethora of available BI methods that can be applied in an improvement project; therefore we have made a selection of five of the most used BI methods to be applied in an improvement project.

Descriptive approaches on the other hand, seek to develop means that reflect how decision makers make choices. The aim of descriptive approaches is not to replace human decision making, but to...
improve the conditions under which decisions are made, by providing added information. Management
science approaches were developed with the normative idea of providing better solutions to complex
problems (Figure 1). Decision support system (DSS) analyses were developed on a more descriptive idea.
The concept of DSS is that models are useful for semi-structured problem analysis. Therefore, decision
maker judgment can be aided by computer support, although the judgment of the decision maker is still
the focus for decision making.

One of the first discussions of DSS came from Little (1970), who primarily addressed the use of
management science models to aid managers faced with a decision. Reviewing the business
environments, Little (1970) noted that real decision making usually involved unstructured problems.
This implies that decisions are often difficult to model, not always fitting the precise format of well-
developed model types. Furthermore, management sciences approaches generally assume that all data
that is necessary, is available. In real life, data is often difficult to get, and the data which is available is
often less reliable than is desired. Furthermore, Little (1970) noted that managers do not often
understand the technicalities of these models. Responsible managers are expected to discount
recommendations from models that are “black boxes”. Little’s conclusions were that support for real
decision making calls for simple, robust models. This aids management understanding of the analysis
results. Models should also be easy to control, so that if a particular manager does not agree with a
particular part of the model, the model can be changed. Models should be adaptive to support the
simple encoding of new understandings of the analyzed system. Moreover, traceability is an important
factor of these models, it should be clear to the decision maker why and how the model comes to a
certain decision.

Therefore, a decision supporting technique should (Little 1970):

- Be easy to understand and use for decision makers.
- Be easy to control and adapt for decision makers.
- Support traceability of the outcome for decision makers.

Keen (1980) advocated the use of an evolutionary approach for DSSs, because users very often do not
know precisely what benefits or what features the DSS will provide them until they see it operating. A
prototyping approach would involve building a small-scale initial system and allowing the ultimate user
to try it out. The user could then give recommendations on redesigns of the prototype. Prototyping is
usually much faster than a full systems development approach and has therefore been chosen as an
approach to design the decision support technique.

2.4. Influential Factors in the Decision Making Process

The objective is to explore the influence of rational and irrational factors in the decision making process,
to be able to understand how decisions are made with regard to selection of BI methods (Descriptive
approach). The most influential factors will be filtered through interviews with consultants to build a
decision supporting technique.

We have extracted three main drivers where the selection of BI methods is based upon from our
literature review (Wieleman, 2011). The first driver ‘Project-based’ targets the sub-drivers concerning a
specific improvement project at a company. ‘Internal environment’ and ‘External environment’ are the two other drivers to function as forces from within and outside the organization, respectively. All the influential factors found in this literature review have been categorized per driver. These influential factors consider rational as well as irrational factors that influence the selection process. We also incorporate irrational factors in our research to assess their magnitude on the decision making process. The definitions of all the criteria can be found in Appendix B.

- **Project-based (Rational)**
  - Expected pay-off of method (Thawesaengskulthai, 2006)
  - Budget available for BI method initiative (Coskun et al., 2008)
  - Time available before first significant improvement (Coskun et al., 2008)
  - Project goals, (Coskun et al., 2008) e.g. devil’s quadrangle (Janssen-Vullers and Reijers, 2005)

- **Internal environment (Rational)**
  - Organizational structure (Näslund, 2008)
  - Size of the company (Näslund, 2008)
  - Past experiences on BI method applications (Thawesaengskulthai, 2006)
  - Information System architecture (Davenport, 1993)
  - Commitment of shareholders, top management and other employees (Siha and Saad, 2008)
  - Industry (Jaffee, 2001; Bititci, 2007)
  - Process Maturity Level (Bititci, 2007)
  - Cultural, Political, Technological and Social (Liman Mansar and Reijers, 2005)
  - Value proposition (Bititci, 2007)

- **External environment (Irrational)**
  - Popularity of BI method (Näslund, 2008)
  - Institutional factors (Wood and Caldas, 2001)
  - Political, Economical, Socio-cultural and Technological (Jobber and Lancaster, 2009)
  - Empirical evidence of BI method’s effectiveness (Thawesaengskulthai, 2006)
  - External customer demand (Liman Mansar and Reijers, 2005)
3. Research Design

The research design (Figure 2) was divided into three main phases: the development of a conceptual background, the design of a conceptual framework and a decision support technique, and the verification, validation and redesign of the framework and technique for selecting BI methods. Verification refers to the use of tests to ensure the accuracy and correctness of the research. Validation refers to the external validity, which has been described as: “the generalizability of research results and conclusions to other people, organizations, countries, and situations” (van Aken et al., 2007).

Figure 2. Research Design
This research will be a theory (prototype) building process which aims to induct theory using case studies. The process of building a theory relies on past literature, empirical observations or experiences and insight of the research that permits the development of a testable, relevant, and valid theory (Eisenhardt, 1989). The case study is a research strategy which focuses on understanding the dynamics present within single settings. It is the development of detailed, intensive knowledge and description involving an empirical investigation of a particular contemporary phenomenon and generation of rich data from a small number of situations (Eisenhardt, 1989). This particular case study will combine data collection methods such as interviews, questionnaires and observations within Infosys, although grounded by academic and management literature to allow generalization of results and designs. The evidence given for the building of the theory will be both qualitative (e.g. words) and quantitative (e.g. numbers) (Eisenhardt, 1989). Each distinct phase in the theory building process will be elaborated next.

3.1. Phase 1: Literature Review
In the first phase, qualitative studies of the literature are examined. This concerns literature regarding improvement projects, BI methods and the role of decision making for the selection of a BI method. From this background, a problem statement and research questions are defined, which allow us to collect specific kinds of data systematically and with a well-defined focus. Furthermore, we identify the most used BI methods in the field which will be taken into consideration: Total Quality Management, Six Sigma, Lean, Business Process Reengineering and Business Process Management. Moreover, a long list of all the influential criteria in the decision making process will be identified. This will be verified and validated within our setting (Infosys) in the next phase to build the selection framework and decision support technique upon.

3.2. Phase 2: Theory Building
In this phase, we will provide an empirical study on the decision making concerning the selection of BI methods. This has been done through questionnaires, semi-structured interviews and observations at Infosys to discover practices concerning business improvement. A selection framework will be designed based on observations during the interviews and a literature review on existing selection frameworks. This framework mainly concerns describing the selection process and positioning the decision support technique in this process. The long list of influential criteria in the decision making process will be shortlisted based on testing the validity of all criteria by Infosys consultants. From the most important criteria the decision support technique will be designed. A review from an academic point of view will be done on the classification of the most influential criteria and decision support systems to build the technique upon. The framework and decision support technique will be designed as the outcome.

3.3. Phase 3: Theory Testing
The conceptual framework and decision support technique provide an input to be verified, validated and redesigned for practical implications in the consulting industry. Therefore, two evaluations have taken place to redesign the framework and decision support technique. The first phase has been done with Indian consultants of Infosys, the second phase has been done with Dutch consultants from both Deloitte and IBM. Through this phase we would like to verify and validate the main deliverables of this research to come to a final design which leads to a generalized design.
Phase 2. Theory Building

In this phase, the theory is build behind the decision support technique to support consultants in the selection of BI methods to apply on an improvement project.

4. The Selection Framework

The proposed framework in this chapter is associated with selection of BI methods for application in an improvement project at an organization. This framework should assist consultants in selecting the most suitable BI methods based on a contextual approach. It provides a structured process in making a rational decision. The main goal of this framework is to position the application of the decision support technique to this process. There is no single BI method that can solve all the problems effectively in an organization (Mohammad, 2010). Therefore, consultants and academicians should try to understand all the relevant BI methods, the organizational profiles, as well as the critical success factors concerning the application of BI methods in an organization.

The framework proposed has both a rigorous and a relevant background. It is based on the academic publications of Thawesaengskulthai (2006) and Mohammad (2010). There are the only articles available in today’s literature on providing a framework for the selection of BI methods in an improvement project. Thawesaengskulthai (2006) based her framework on the general management and operations management literature. Basic operations strategy concerns the degree of fit between the company’s objectives and each particular BI method. It starts with three simple, sequential questions that a company has to ask itself:

- Where are we now?
- Where do we want to go?
- How do we get there?

Thawesaengskulthai (2006) allowed us to elaborate how these questions can be applied to design the first three steps in our framework, where a company defines the characteristics of the improvement project and sets goals. Furthermore, Thawesaengskulthai (2006) also identified two main influential factors: ‘Barriers to Start’ and ‘Critical Success Factors’ in an improvement project, which will be explained in more detail in the next chapter. Mohammad is currently finishing off the development of the GUIDE model, which highlights the steps to undertake to select BI methods. GUIDE stands for:

1. Goal Setting
2. Understand organizational context
3. Identify relevant organizational initiatives
4. Decide on the appropriate initiative
5. Evaluate the decision

Though not published yet, we have approached him to get a detailed look into the model that he has developed. This model is different from other academic literature as it highlights the need to understand an organization’s profile as well as providing a holistic selection process, which were not explicitly presented in the model of Thawesaengskulthai (2006).
These frameworks were compared with a framework provided by Infosys Consulting, known as the Impact Framework. This framework cannot be disclosed concerning intellectual property (IP) rights of Infosys, but it describes how the first three steps of the GUIDE model should be applied to improvement projects. It provides a complementary holistic selection process similar to the GUIDE model by Mohammad from a practical point of view.

Based on evaluations conducted at Infosys, IBM and Deloitte, we were able to refine the characteristics of the framework. The framework is presented to you on the next page and will be elaborated for each step in the process of selecting BI methods to apply in an improvement project at an organization.
**Framework for Selecting Business Improvement Methods in an Improvement Project**

### Barriers to start
- Top management support
- Provision of sufficient resources
- Willingness to change

### Critical Success Factors
- Capabilities of Workforce
- Change management
- Leadership and communication

### Trigger to start
1. **Handle increasing complexity**
2. **Survive in dynamic market**
3. **Explore new markets**
4. **Sustain competitive advantage**

### Define
1. Define the problem statement
2. Define the desired state
3. Define the stakeholders involved

### Set the preconditions for improvement
1. Set the project scope, budget and duration
2. Set the project goals
3. Set the expected pay-off

### Understand the environment
1. Understand the company's vision, mission and values
2. Understand the organizational context
3. Understand the organizational characteristics

### Identify relevant BI methods
1. Individual assessment by decision makers
2. Decision Support Technique

### Decide to apply the appropriate BI method(s)
1. Discussion between decision makers

### Evaluate the effectiveness of the decision
1. Check whether the applied method(s) reached the project goals

### Learn from Evaluation

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4.1. The Characteristics of the Selection Framework
The framework is formed by the basic selection process that should provide any organization with an improvement project with different activities that are usually executed in sequential order. There are seven different steps defined which will be elaborated step by step. Furthermore there are three different colors used to indicate the organizations that should be involved in a particular step. The beginning of an improvement project will be executed by the company that starts an improvement project, defines the project’s characteristics and sets the preconditions (light blue). In most improvement projects a consulting firm will be asked to study the environment when an RFP has been sent out (white). Once the consulting firm has been contracted to work on a particular improvement project, the selection of BI method(s) will start. Both parties will have to identify the relevant BI methods, decide which BI method(s) to choose for the improvement project and ultimately evaluate this decision to learn from it for future projects (dark blue). The decision support technique should be used to identify the relevant BI methods to apply on the improvement project.

Furthermore, there are two main factors that drive the selection of BI methods in an improvement project. The first one is “Barriers to start”, these are the factors that determine if a proposal from within the business for an improvement project is accepted and supported so the selection process for a BI method can start. The factors of “Barriers to start” (Thawesaengskulthai, 2006) are:

- Top management support
- Providence of sufficient resources
- Willingness to change

The second main factor that drives the selection is more concerned with the effectiveness and success of the application of the BI method to the improvement project. As the appropriate BI method(s) are selected, they will have to be applied and in order for them to be successful, the following factors will have to be in place (Thawesaengskulthai, 2006):

- Capabilities of the workforce
- Change management
- Leadership and clear communication

In the next paragraphs the steps of each of the selection processes will be further elaborated.

4.1.1. Triggers to start
This step in the selection process is concerned with the motivation for the start of an improvement project for a specific business function, business process or to explore a new market. This motivation is based upon triggers such as: handling the increasing complexity of processes, the survival in a dynamic market, the exploration of new markets or to sustain competitive advantage.

4.1.2. Define
In this step of the process the definition of the improvement project takes place. It has to be a structured document where a department has to elaborate what the current problem is and what the desired state is. Moreover, the stakeholders influenced by this improvement project will have to be
analyzed so that they can be involved in the improvement project. The stakeholders’ acceptance of the
details of the improvement project is one of the determinants for the success in an improvement
project. Moreover, an organization has to cope with the other barriers in order to be able to start with
the improvement project.

4.1.3. Set the preconditions for improvement
In this step the barriers to starts have been overcome and the improvement project will be started.
Together with top management and other stakeholders the scope, budget and duration of the project
has to be set. Moreover, the project goals and the expected pay-off of the improvement project have to
be defined.

4.1.4. Understand the environment
After the preconditions have been set for this particular project a Request for Proposal is sent out to
consulting firms. This RFP is an invitation to a consulting firm to submit a proposal on their consulting
services. For them to submit a proposal they will have to understand the specific improvement project
and the organizational environment. Specifically, they will have to look into the preconditions set
concerning the improvement project from Step 3. Moreover, they will need to understand the specific
company’s environment and organizational characteristics through the company’s vision, mission and
values.

4.1.5. Identify relevant BI methods
Based upon the project-related factors and organizational characteristics, a company with an
improvement project and the contracted consulting firm has to select the most relevant and appropriate
BI method(s) for this particular project. This should ideally be based upon an individual assessment by
each of the decision makers from both parties. However, from interviews with consultant from Infosys,
IBM and Deloitte we could conclude that these individual assessments are very subjective. This is the
stage in the selection process where the decision support technique should come into play to support
the decision making process of consultants in the improvement project.

4.1.6. Decide to apply the appropriate BI method(s)
After each decision maker assessed which BI method(s) should be applied to a specific project, a plenary
session should be held to discuss the assessments. This should be complemented with the judgment
provided by the decision support technique filled to provide further input into the discussion. As the DST
is liable of the subjectivity of the user, the decision makers should reach a consensus on the input
variables in the DST to come to a clear conclusion. From these steps the most appropriate BI method(s)
will be selected and applied on the improvement project. During the application of the method(s), the
critical success factors come into play to determine the effectiveness of the application.

4.1.7. Evaluate the effectiveness of the decision
After the duration set by the project, the application of the BI method will have to be evaluated on the
achieved effectiveness of the improvement project. This evaluation should lead to an input to both
decision makers and the decision support technique to adapt their judgment process if the applied
method was less successful as beforehand aimed for.
5. Data Collection

After the conceptual background has been shaped and the selection framework has been explained, we start with data collection among consultants. Interview data enabled the researchers to get an in-depth understanding and explanations about the decisions regarding selecting a BI method to apply at an improvement project. First the data collection process will be explained in more detail, after which a limitation in the data collection process will be discussed.

5.1. The Data Collection Process

Prior to the interviews, a first meeting with key contact persons within the departments Infosys Labs and Infosys Consulting were set up to identify relevant people for interviews. All the interviewees have at least five years of experience in the consulting industry. Moreover, these consultants were all involved in the decision making process for selecting a BI method at past improvement projects. We have conducted 15 different interviews with employees from Infosys Technologies Limited. Their names and job titles can be found in Appendix C. The process of each interview was set up as follows:

At first, we send out a questionnaire which the consultants had to fill in before the interview was conducted. This questionnaire can be found in Appendix D. This questionnaire provided background to the researchers about each interviewee. This allowed the interviewer to relate the questions asked during the semi-structured interview to the answers of the questionnaire and ask for examples during recent application of BI methods at improvement projects. The semi-structured interview took between thirty minutes to one hour per candidate, where the format of the interview can be found in Appendix E. The interview format is important to guide the collection of data because it will enhance the reliability and validity of the research (Eisenhardt, 1989). The semi-structured interview went into more depth about the background of the interviewee and asked for further elaboration on criteria taken into consideration in their recent decision making at improvement projects. During the interview, we also tried to gain more insights in practices in the field of business improvement. Note that the consultants were not informed before the interviews about the findings of influential criteria from the literature review (Wieleman, 2011). It would have biased their answers during the interviews. This was done on purpose, because after the interview a last document was sent to each interviewee where he/she was asked to rank the extracted influential criteria in the decision making from the literature review (Wieleman, 2011) on their degree of importance in the selection process of BI methods (see Appendix F). This ranking allowed us to select the most influential criteria in the decision making process. In addition, this allowed us to see whether the interviewees mentioned the same criteria during the interview as were found in the literature. In that way, we observed whether the academic literature and practice have a consistent view on the influence of criteria on the decision making process.
consultants were provided the option in the ranking form to provide new criteria which have not been extracted from the literature, but which do play a role in the decision making process according to their experience.

5.2. Limitation in Data Collection

The design of the decision support technique is based on the findings from the data collection. Moreover, from the findings we could also position the decision support technique in a selection framework. We aimed to schedule 20 interviews but this was not possible due to resource and time constraints. Nevertheless, after conducting 10 interviews we found that the observations from the interviews were very similar and hardly any new findings were reported as interviews progressed. This implies that we reached a representing sample from the consultants at Infosys. Note that there are estimated to be around 150 consultants working at Infosys Consulting in Bangalore and not every consultant would conform to the requirements mentioned in the beginning of this chapter. The next step in this research will be to analyze the data.
6. Data Analysis

At first we will provide the background of the interviewees which we interviewed from Infosys. We will provide tables of their familiarity and experience with the five different BI methods and in other proprietary methods. Secondly, irrational forces influencing the decision making process will be elaborated upon. Thirdly, the consistencies between the rankings of the criteria between academic literature and practice will be discussed. Fourthly, we analyzed the need among the interviewees for a decision support technique positioned in a guiding framework. As a last section, we will look at the rankings of the influential criteria by the consultants and determine which criteria have been selected to use in the decision support technique.

6.1. The Familiarity with BI Methods

In Table 2, the familiarity with the main concepts of all the BI methods as well as the experience at applying the BI methods in improvement project can be found from the fifteen interviewees. We can clearly see that TQM is not a business improvement method where consultants are familiar with these days. Moreover, the experience in applying TQM at improvement project is very low. We can see that the other methods score fairly similar with regard to familiarity of the concepts and experience in applying the method. However, we could see that a lot of the consultants have experience in applying BPR at improvement projects. This is different from the findings in literature, which suggest that BPR was the most popular BI method during early to mid-1990s, however it then became connected with downsizing and lay-off and the popularity of applying the method decreased. When data from new research on downsizing and lay-offs did not support these contentions, BPR went from being a dramatic solution for business improvement, to being just another among many “change management” philosophies (Dervitsiotis, 1998). We have to remain critical when drawing conclusions from these data as the application of BI methods in improvement project may be country-specific (Näslund, 2008).

\[
\begin{array}{|c|c|c|c|c|c|}
\hline
 & TQM & Six Sigma & Lean & BPR & BPM \\
\hline
\text{Familiarity with main concepts} & 4 & 10 & 10 & 12 & 11 \\
\hline
\text{Experience in applying} & 2 & 9 & 8 & 12 & 9 \\
\hline
\end{array}
\]

Table 2. Consultant’s Background regarding BI methods

During the interviews we also asked about other methods which were used within Infosys for business improvement. Within Infosys Consulting there is a proprietary framework used to guide the process of improving a company’s core business process(es). This framework is called the ‘Impact Framework’ but we did not get the permission to explain the framework in this publication, because of confidentiality reasons. However, we can mention that there is a part of the framework which concentrates on the selection of tools to be used to improve the performance of an organization. The techniques used by Infosys Consulting are basically blended from the techniques of known BI methods and complemented with best practices from the experience of senior consultants. Infosys Consulting strives to use most of the different techniques inside their framework as their projects mainly focus on transformation projects. The difference between transformation projects and improvement projects is the scale of the
project. Transformation projects concern the complete rethinking of business processes at organizations. It basically impacts all business processes within a company on the operational level, managerial level and level of support. This also explains why most of the consultants have the most experience with BPR, as this method supports the radical rethinking of business processes. Nevertheless, when there are limited resources available for the transformation, a senior consultant of Infosys still has to choose to use one technique over another, leading to a similar decision making problem as discussed in this research. Infosys Consulting tries to optimize the value an organization can bring to its customers, but their selection process for the most valuable techniques in an improvement project is yet undefined.

6.2. Irrational Forces in the Decision Making Process

From the interviews and evaluations with Infosys, IBM and Deloitte we could make a model (Figure 3) which describes two irrational forces which influence the decision made on the selection of BI methods. This model describes forces both from the perspective of the company with an improvement project as well as the contracted consulting firm.

![Figure 3. Capability Push - Demand Pull Model](image)

These forces play a role when a ‘Request for Proposal’ (RFP) is sent out to consulting firms and will argue the objectivity of the selection process. An RFP is issued at an early stage of a procurement process of an improvement project where an invitation is presented for consultants, often through a bidding process, to submit a proposal on their consulting services. The first irrational force that comes to play a role in that process is described as the “Demand Pull”. This force is related to the criteria “Past experience on BI method applications” and “External customer demand”. The management of the company may have read in a management book about how a particular BI method is the ‘all-curing medicine’ to any company’s problem. The management will then urge the consulting firm to select this particular method independent of the specific characteristics of the company and its improvement project. Another way the “Demand Pull” can be interpreted is when a company already has experience with a specific BI method applied at former improvement projects. This company can have trained employees how to manage and execute a project concerning a specific BI method. Master Black Belts (Six Sigma), Lean Coaches (Lean) and BPM Architects (BPM) are examples of job titles which trained employees can get. These employees can bias their management to choose their favorable BI method at an improvement project.
The second irrational force that can come from the consulting firm is described as “Capability Push”. This is defined as when a consulting firm makes their RFP and looks at the available resources and expertise which can be applied to the demand of the company with an improvement project. When there are no consultants available which have an expertise in a specific BI method, it will not be taken into consideration in the selection process of BI methods by the consulting firm. When a consulting firm has no consultants experienced in a specific BI method, this method will not be taken into account at all in the selection process. Another irrational force is that the selection of BI methods heavily relies on consultant’s preferences and experiences in the application of a specific method and its techniques. From the interviews we could notice that each consultant has its preferred set of BI methods to apply at an improvement project with which they are most acquainted with. For instance, we interviewed a consultant who was trained in Six Sigma as a Black Belt and applied Six Sigma-specific techniques in all of his past improvement projects. For new improvement projects, the consultant was always biased to favor this preferred method (Six Sigma) over other BI methods. If a consultant is most acquainted with a specific method, it will affect the objectivity of the selection process concerning BI methods. This could result in a missed opportunity by not analyzing any of the other BI methods available.

These forces have not yet been described earlier in the existing academic literature and play a role in Step 5 and Step 6 of the selection framework in Chapter 4. These forces should be minimized in order to increase the rationality of the decision making process when selection BI methods.

### 6.3. Consistency of Ranking Influential Criteria

From Table 3, we can see the most frequently mentioned influential criteria in the decision making process during the interviews. Moreover, the most commonly mentioned criteria were in the drivers Project-based and Internal Environment. Criteria from the External Environment were not mentioned frequently during the interview. From this observation we can establish that the decision to apply a BI method involves a high influence from rational considerations of multiple criteria. Moreover, ten interviewees mentioned that there is a certain need for rational support within the selection of a BI method to apply at an improvement project. “This should be done through a guiding framework and a supporting model through which a consultant can easily eliminate inapplicable BI methods” (quote).

<table>
<thead>
<tr>
<th>Project-based</th>
<th>Budget available</th>
<th>Time available</th>
<th>Expected pay-off</th>
<th>Project goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2</td>
<td>9</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal Environment</th>
<th>Past experience</th>
<th>Organizational structure</th>
<th>Company size</th>
<th>Company industry</th>
<th>Process Maturity</th>
<th>Maturity Value proposition</th>
<th>Internal PEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>1</td>
<td>6</td>
<td>13</td>
<td>8</td>
<td>10</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>External Environment</th>
<th>Popularity of method</th>
<th>External PEST</th>
<th>Journal recommendation</th>
<th>Colleague recommendation</th>
<th>Management guru recommendation</th>
<th>Following competitors</th>
<th>Empirical evidence</th>
<th>External customer demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

*Table 3. Frequency of External Environment Criteria*
There were no new criteria suggested during the semi-structured interviews which were not already extracted from the Literature Review (Wieleman, 2011). Thus, we can conclude that the academic knowledge concerning influential criteria in the selection process of BI methods is satisfactorily.

6.4. Need for the Decision Support Technique

Table 4 provides the number of interviewees that mentioned each of the statements during their interviews. This allows us to conclude that there certainly is a need to design a decision support technique positioned in a selection framework to support the selection of BI methods. A decision support technique would not be needed to allow faster decision making, rather structural and rational decision making. According to five interviewees, the consulting industry lacks a framework to do consulting, they rely too much on their experience. Therefore, decision making in selection of methods is only done by senior consultants. The next chapter will select the most influential criteria to be used in the decision support technique aligned to company’s priorities and context-specific variables.

<table>
<thead>
<tr>
<th>Statements</th>
<th>No. of interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘There is a need for more structural decision making’</td>
<td>12 of 15</td>
</tr>
<tr>
<td>‘There is a need for more rational decision making’</td>
<td>8 of 15</td>
</tr>
<tr>
<td>‘There is a need for faster decision making’</td>
<td>1 of 15</td>
</tr>
<tr>
<td>‘There is a need for a decision support technique’</td>
<td>11 of 15</td>
</tr>
</tbody>
</table>

Table 4. Statements of interviews

6.5. Criteria Selection to Use for the Decision Support Technique

In Appendix G, we presented the mean, mode and standard deviation from the rankings of the criteria filled in by 12 of the 15 interviewed consultants. As a cut-off point we have taken all the criteria above 3.5 as mean to be considered in our decision support technique. The mean score 3.5 represents a score between medium importance (3) and high importance (4) of the specific criterion on the decision making process of selecting BI methods for application at an improvement project. The selected criteria for the decision support technique are:

✓ Project Based: (1) Project Goals, (2) Expected pay-off of method
✓ Internal Environment: (3) The company industry, (4) Process Maturity Level, (5) Value proposition
✓ External Environment: (6) Popularity of the method

The influences of the criteria ‘Past experience on BI method applications’ and ‘External customer demand’ on the selection process of BI methods were explained in Chapter 6.2. These will not be taken into consideration for the design of the decision support technique as these criteria question the objectivity of the selection process of BI methods. The next chapter will describe the main deliverable of this research, the Decision Support Technique (DST).
7. Decision Support Technique
In this chapter the DST will described which can be used in identification of BI methods relevant to the specific company characteristics and their improvement project. The DST can be found in Appendix N.

7.1. Approach of the Decision Support Technique
The DST will be divided into three different phases. These phases have been developed through the combination of decision models available in the academic literature and the interviews with consultants from Infosys. The first phase (Elimination-based) was developed as 7 (of 15) consultants suggested that in their selection process they first eliminated inapplicable BI methods based upon organizational characteristics of a company. The other two phases were developed using the standard multi-criteria decision making approach (Triantaphyllou, 2000), were a score is calculated to rank alternatives, from where the results are analyzed in a sensitivity analysis. The DST was developed in Microsoft Excel spreadsheets as this application is capable of modeling, well understood in business and commonly used in various practical situations (Balakrishnan et al., 2007).

7.1.1. Phase 1: Elimination-based
Through the conducted interviews we could conclude that consultants first use an elimination-based approach in their selection of possible BI methods. Based on the organizational characteristics and context of a company with an improvement project, some BI methods cannot be selected.

We will start off with our defined collection $A$ of BI method alternatives as:

$$A = \{TQM, Six\text{ }Sigma, Lean, BPR, BPM\}$$

This step will lead to a collection $A'$ where the following condition holds:

$$A' \subseteq A$$

Filling in the organizational characteristics of the company with an improvement project will lead to a subset ($A'$) of the collection of methods available to choose from ($A$). The organizational characteristics of a company are assumed to be fixed at the time the DST will be used.
The variables of the influential criteria have categorical values. The influential criteria from the Internal Environment from Chapter 6 are:

- The company industry
- Value proposition
- Process Maturity Level

The classifications of these criteria and their use in the DST will be provided in Chapter 7.22.

7.1.2. Phase 2: Scoring Model
The second phase of the DST will make use of a scoring model to provide the consultants with a ranking of the best alternatives of the set of alternatives selected from Phase 1. This will allow the best scoring alternatives to be integrated when selecting the most suitable BI methods for a specific improvement project.

Companies in an improvement project can set their own expectations and goals for an improvement project. These expectations and goals will have to be aligned with the expectations and goals that can be accomplished by the different BI methods. The Project-based criteria Project Goals and Expected pay-off will be used for the scoring model. These will be classified and ultimately given numerical values for each of the BI methods. Moreover, the Popularity of the BI methods has also been taken into consideration, but will be out of control to the consultants. In order to keep this criterion as objective as possible, we choose to control it from an academic perspective compared to letting a subjective consultant control the variable. Consultant’s perceptions of the popularity of BI methods differ between countries and consulting firms (Benders and Van Bijsterveld, 2000). As we are targeting to design a DST applicable to the worldwide consulting industry, we have chosen to take an academic perspective to estimate the worldwide popularity of BI methods. Therefore this criterion will be fixed based on the popularity of the BI methods in the academic literature and will also be given numerical values based on the number of publications in 2010.

The scoring method will make use of Multi-criteria Decision Making (MCDM). MCDM models can be very useful in aiding decisions. It is a prominent class within DSS research, which involves the evaluation of a finite set of alternatives in terms of a finite number of decision criteria (Triantaphyllou and Baig, 2004).

There are three steps in utilizing any decision making technique involving numerical analysis of alternatives (Triantaphyllou and Mann, 1989):

1) Determining the relevant criteria and alternatives
2) Attaching numerical measures to the relative importance of the criteria and to the impacts of the alternatives on these criteria
3) Processing the numerical values to determine a pre-defined goal of the analysis.

The relevant criteria and alternatives for have already been determined. The other two steps in utilizing the decision making technique will be provided in Chapter 7.3.
7.1.3. Phase 3: Sensitivity Analysis

The third phase of the DST will provide a sensitivity analysis. It is important for the DST to provide a sensitivity analysis to increase the understandability of the influence of quantifying qualitative data to the decision maker and to provide traceability of where the ranking of alternatives is based upon.

If decision makers know how sensitive the ranking of alternatives is, they will be more confident in using the DST and how changes to the importance of criteria can alter the ranking provided. Therefore, a score robustness analysis will be performed on the relative importance of the criteria. Moreover, graphical displays will be provided through graphs to provide insights to the user for the scores of each criterion per BI method. These two parts provide both a quantitative and graphical analysis on the sensitivity of the scores. A more detailed description of these methods will be provided in Chapter 7.4.7.4.

7.2. Phase 1: Elimination-based

This chapter will describe how the criteria of phase 1 were classified (Industry, Value proposition and Process Maturity Level) and how these classifications have been implemented in the elimination-based approach in the DST. Screenshots of this phase of the DST and an elaboration on the design can be found in Appendix N1.

7.2.1. Industry

The classification of industries was not very straightforward. A rigorous classification of industries could not be found, that is why we had to turn to practice for a classification. The classification that will be used is based upon a classification used by Van Wijk (2009) in his research on organizational characteristics’ influence in carrying out BPM projects. His classification is based upon the classification used by the Dutch chamber of commerce (in Dutch: “Kamer van Koophandel”) and the internal industry classification used by Deloitte Consulting. The classification was compared with the industries in which Infosys’ consultants had experience, in order to validate the classification. The procedure used was to examine whether all the different cases that Infosys’ consultants spoke about in the interviews could be classified in one of the categories of the industries by Van Wijk (2009). The interviews with Infosys Consultants provided us with 26 separate cases in different industries used for the validation process. From this validation process, we could conclude that 20 separate cases of improvement projects (of 26) in different industries could be categorized under one of the industries of Van Wijk (2009). The classification is complemented with a new industry IT, as this concerned the six remaining cases, which could not be categorized under the existing categorization of Van Wijk (2009).

The combined classification will be used to classify business improvement industries. The categories defined together with their acronyms are:

- Consumer Business (CO)
- Energy & Utilities (EN)
- Financial Service Industry (FI)
- Governmental Authorities (GO)
- Healthcare (HC)
- IT (IT)
- Manufacturing (MA)
- Technology, Media & Telecommunication (TE)
- Transportation & Aviation Services (TR)
7.2.2. Value Proposition

Managing value created to the customers of an organization has become critical for survival and growth in today’s dynamic markets. Many organizations still fail to identify their value propositions, particularly in aligning their resources and capabilities with their value creation processes. Prahalad and Hamel (1990) and Porter (1985) agree that every company has to focus their resources on one objective. These authors sustain that companies have to focus on one value proposition that it can deliver to a selected market. Therefore, the value proposition is defined as: the predominant strategic orientation of the improving business unit leading the business improvement project.

Empirical research (Martinez, 2003) supports that it is more appropriate to apply the value proposition at the level of business units. Especially because an organization can have two or more business units with different strategic positions, serving different market segments with different competitive requirements, have different product strategies and have different perceived brand images by their markets (Bititci, 2006).

Bititci (2006) has proposed and evaluated a framework for aligning a value proposition within a company. A set of guidelines are constructed on how an organization could align, direct, and manage its capabilities to create and manage value. The value propositions directly align the corporate objectives and core competencies of an organization to the customers’ expectations. Bititci (2006) classifies six different value propositions and constructs them in a value matrix based on two axes. The first axe is the differentiation between values (Martinez and Bititci, 2001), it underpins the applicability of technology, research and development, marketing, sales and service management, in order to serve current and future needs of a complex market. Hard Value is focused on continuous creation of technology on products and services regarding process innovations and improvement of activities. In contrast Soft Value is more focused on the organizations’ marketing image and management. Soft Value stresses into psychological perceptions (intangible) like brand image, feelings of customers, customer attention. The other dimension is based upon original value propositions from Treacy and Wiersema (1993): Customer intimacy, Operational Excellence and Product Leadership. The defined framework by Bititci (2006) allows a better classification than the one-dimensional view based on strategic orientation developed by Treacy and Wiersema (1993). The result is a 3 x 2 matrix as depicted in Table 5. Appendix H provides some examples of companies that fit into each of the six categories. Moreover, the value propositions have been explained in more detail.

<table>
<thead>
<tr>
<th></th>
<th>Hard Value</th>
<th>Soft Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Leadership</td>
<td>Technology Leaders</td>
<td>Brand Leaders</td>
</tr>
<tr>
<td>Operational Excellence</td>
<td>Price Minimizers</td>
<td>Process Simplifiers</td>
</tr>
<tr>
<td>Customer Intimacy</td>
<td>Technological Integrators</td>
<td>Social Integrators</td>
</tr>
</tbody>
</table>

Table 5. The Value Matrix (Bititci, 2006)
7.2.3. Process Maturity Level
During the interviews it was frequently mentioned that the capabilities and maturity of the company is an important criterion that influences which BI method to select for application in an improvement project. This chapter we will reflect on the available methodologies in literature to define an organization’s capabilities and maturity to select the best suitable methodology to this research. First, we will explain the necessity of an organization to increase their maturity and what benefits this can bring to the whole organization.

Standard processes help an organization to achieve their business objectives by helping them work not harder, but more efficiently and with improved consistency (Lee and Lee, 2009). A business process maturity model provides standards and measures to organizations in assessing, defining and improving business processes, thereby guiding them to achieving business goals and values. It helps an organization set priorities for improving its product/service using a proven strategy and for developing the capability required to accomplish its business values (Lee and Lee, 2009). Certain BI methods are more effective when applied at organizations with a high maturity level. For instance, Six Sigma would need to be applied in mature organizations where quality is measured for important pre-defined process activities across a project.

The Capability Maturity Model (CMM) was originally developed to assess software processes, designed by the Software Engineering Institute (SEI). The CMM for Software provides software organizations with guidance on how to gain control of their processes for developing and maintaining software and how to evolve toward a culture of software engineering. The CMM was designed to guide software organizations in selecting process improvement strategies by determining current process maturity and identifying the few issues most critical to software quality and process improvement. The Capability Maturity Model Integration (CMMI) was then developed by Carnegie Mellon University as an approach to enhance process improvement for the organization as a whole. However, we have to be critical as CMMI originated in software engineering and has from that point been generalized. This generalization makes this model extremely abstract and will therefore not be used to indicate the maturity of an organization although it has been used by practitioners, as was mentioned during the interviews. Moreover, business processes are considered as having multi-dimensional and non-linear characteristics, unlike the software project life cycle (Fisher, 2004).

The Business Process Maturity Model (BPMM) is based on these models and proposed to be used for BPM adoption (Rosemann and De Bruin, 2005). This model is still under development and is practically applied to a limited extent (Van Wijk, 2009). Moreover, this model may cause problems of interpretation by practitioners through its complex three dimensional structure. Some other maturity models available in literature are the Process Maturity Model (PMM) and Process Management Maturity Model (PMMM), but these are not elaborated to a detailed level to apply in practice (Lee and Lee, 2009).

The value-based Process Maturity Model (vPMM) was developed by Lee and Lee (2009) to overcome the weaknesses of current maturity models. vPMM includes business process management maturity like BPMM and Hammer’s Process and Enterprise Maturity Model (PEMM) (Hammer, 2007). A business
process should not focus on a process only; it should also focus on enterprise values because the ultimate purpose of a business process is to achieve business values. In that way, a business process that does not contribute to business value achievement should be improved or adjusted to contribute business value creation. This model creates an extra dimension by linking the maturity of the organization to their business value capability. The vPMM therefore connects directly to another influential criterion in the selection of BI methods: the value proposition.

The vPMM has a five-level structure like the other discussed models. The maturity level of the vPMM can be used to determine the maturity of an organization’s current business process practices by considering an organization’s business value creation capability as well. This will ultimately help an organization set priorities for improving if operations using a proven strategy to accomplish its business values.

vPMM reflects two aspects. Figure 4 illustrates each of the maturity levels from both aspects. The vPMM is a process maturity model that provides guidance on which capabilities should be embodied in an organization for implementing business values. As an organization achieves goals on each maturity level of the vPMM, an organization is viewed as having the capability for accomplishing the corresponding business value. Moreover, the vPMM identifies generic business process areas with the viewpoint that any business process essentially belongs to one of the four generic kinds of activities – Input, Mechanism, Control, and Output (IMCO) (NIST, 1993).

<table>
<thead>
<tr>
<th>Name</th>
<th>Process Maturity Explanation</th>
<th>Business Value in Process Maturity</th>
<th>Input, Mechanism, Control, and Output</th>
</tr>
</thead>
</table>
| **Level 1: Initial Level** | • Processes are not defined, measured or controlled  
• Improvement projects are uncoordinated, isolated and done on an ad-hoc basis | • A very immature organization, which is not able to reach any standardized business value achievement out of their improvement initiatives. | Undefined |
| **Level 2: Managed Level** | • Process is partially defined  
• Measure process performance partially  
• Unable to use the performance data for process improvement | • Value associated with process are not defined  
• Measure value achievement performance (black box) | |
| **Level 3: Defined Level** | • Process is defined  
• Measure process performance  
• Use the partial performance data only in an ad hoc way for process improvement | • Value associated with process are defined  
• Measure value achievement performance (gray box)  
• Use partial value achievement performance data only in an ad hoc way for process improvement | |
Level 4: Quantitatively Managed Level
- Measure process performance quantitatively
- Use performance data in an ad hoc way for process improvement
- Measure value achievement performance quantitatively
- Use value achievement performance data in an ad hoc way for process improvement

Level 5: Optimizing Level
- Systematically use process performance data to improve and optimize process
- Systematically use value achievement performance data to improve and optimize process

Figure 4. Process Maturities and their Business Values of the vPMM

The vPMM will be used for the DST as the organization’s competence for achieving their business values has been taken into consideration in their business process maturity model. Achievement of business value is an important goal of organizations with improvement projects (Prahalad and Hamel, 1990). We have to remain aware that a complex measurement is required to assess the value Process Maturity Level for a specific business unit within a company leading the improvement project. We do not see this as a big problem, as an approximation should be made by several consultants when using the DST, as described in the selection framework. Subsequently, the decision makers will have to examine each other’s input data in the DST and come to a consensus about the vPML of a company.

7.2.4. Elimination-based Implementation in DST
The instances for each criterion and their abbreviations can be found in Appendix I. Based upon interviews with consulting experts from Infosys, IBM and Deloitte the following table of constraints could be made. Moreover, we have done research within the academic literature to look for verification of the claims. We could not find a lot of research on the exclusion of BI methods under certain organizational characteristics. This is a real gap in literature where future research can provide means to improve the accuracy and validity of the claims regarding the exclusion.

Any of the instances in Table 6 will cause the BI method to be eliminated from possible selection and will not be taken into consideration in the remainder of the DST. The criteria used in this phase of the DST are the selected criteria from the Internal environment: (1) Industry, (2) Value Proposition and (3) Value Process Maturity Level. Each number next to each cell represents the number of consultants that claimed this elimination to take place. If no number is provided next to a claim, then the claim is based upon literature.
7.2.4.1. **Industry-based Elimination**

For TQM, Six Sigma and Lean no specific industry constraints could be found. They seem to be BI methods that can be applied to any particular industry. With Lean it was argued by four consultants that it cannot be applied to industries where it is hard to find direct value-add in the activities. This counts for the Healthcare industry, the IT industry and the Finance Industry. In these industries the value-add to the customers is argued to be intangible. Nevertheless, in response by consultants in the evaluation of the DST, we could not find any support for this statement. Therefore a clear distinction in which industries Lean could be applied has not been used in the DST.

For the process-oriented methods BPR and BPM, four consultants claimed these methods were not popular in the Manufacturing and Transportation industry. The traditional methods born in the Manufacturing (TQM, Six Sigma and Lean) were only accepted there. We could find some support from Van Wijk (2009) who showed in his research that there was not a significant difference in the application of BPM to improvement projects between the Manufacturing and Non-Manufacturing industry. Therefore we choose to not exclude BPM when a company is operating in the Manufacturing industry.

7.2.4.2. **Value Proposition-based Elimination**

From Reed et al. (1996) we could conclude that TQM components are based upon a value proposition targeting either the customers or the operations of a company. They concluded that TQM has not been characterized to be applied to companies who pursue Product Leadership. This leads to the exclusion of variables of Brand Leaders and Technology Leaders for TQM. A similar claim was provided by five consultants for BPR.

Companies who pursue to be Social Integrators may not fit into the propositions targeted by Six Sigma. Social Integrators are companies who have a vision to be flexible towards a small amount of customers. Flexibility to customers is something that you want to avoid in a Six Sigma application as was claimed by six different consultants.

From Van Wijk (2009) we could see that companies applying BPM pursuing Product Leadership almost always have a technical objective to apply. This leads to the exclusion of BPM application to companies with the value proposition Brand Leaders.

<table>
<thead>
<tr>
<th>BI Methods</th>
<th>TQM</th>
<th>Six Sigma</th>
<th>Lean</th>
<th>BPR</th>
<th>BPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td></td>
<td></td>
<td></td>
<td>{MA, TR}</td>
<td>4</td>
</tr>
<tr>
<td>Value Proposition</td>
<td>{TL, BL}</td>
<td>{SI}</td>
<td>6</td>
<td>{TL, BL}</td>
<td>5</td>
</tr>
<tr>
<td>Value Process Maturity Level</td>
<td>{1}</td>
<td>6</td>
<td>{1,2} (Salunga, 2007)</td>
<td>6</td>
<td>{4,5} (Salunga, 2007)</td>
</tr>
</tbody>
</table>

Table 6. Constraints per BI method for each criterion
7.2.4.3. **Value Process Maturity Level-based Elimination**

For the methods of TQM and Six Sigma, it was argued by six consultants that these cannot be applied to organizations that have an undefined, unmeasured and unstructured process. These methods have a higher effectiveness to organizations with a higher value-based process maturity level (vPML).

Moreover, Salunga (2007) has connected Lean and Six Sigma to the maturity level of organizations. Lean and Six Sigma can complement each other. The key to blending these methods is the proposed alignment with the business process maturity. Process improvement teams should employ Lean tools and methods to discover and define their processes during the early phases of process maturity and use a blend of Lean and Six Sigma tools to refine their processes. Once the processes become measurable and workflows become streamlined, Six Sigma should be utilized. This has led to the exclusion of Lean on vPML 4 – 5 and the exclusion of Six Sigma on vPML 1 – 2.

BPR was argued by eight consultants not to be used on a vPML higher than 3. To radically redesign your business processes when measurement of the standardized and integrated process performance is in place was argued not to be effective to companies (vPML 4). The same argument counts for a company that has a systematic way of improving and optimizing processes (vPML5).

When there is already a systematic improvement culture in place at a company (vPML5), it was argued by five consultants that no benefit will be found from the method BPM.

7.3. **Phase 2: Scoring Model**

This chapter will describe how the criteria of phase 2 were classified (Project goals, Expected pay-off and Popularity of the method) and how these classifications have been implemented in the scoring model in the DST. How these classifications will be used in the DST is explained in Chapter 7.3.4. – Chapter 7.3.7.

7.3.1. **Project Goals**

The criterion ‘Project Goals’ is based upon the alignment of the BI method to a company’s vision or objectives. In this criterion, consultants will assess the BI methods against the operational objectives of a company’s improvement project. The typical operational objectives such as time, cost, flexibility and quality (Zairi, 1997) will be used to measure company’s project goals as they are widely used. Brand and Van der Kolk (1995) distinguish the same four main dimensions in the effects of process redesign measures. These are dimensions that are reoccurring in literature on business improvement (Zairi, 1997; Harrington, 1991) and were also frequently mentioned during the interviews with the consultants. Ideally, the improvement of a business process decreases the time required to handle the case, it decreases the required cost of executing the business process, it improves the quality of the service delivered, and it improves the ability of the business process to react to variation (Limam Mansar & Reijers, 2005). The appealing property of the model of Brand and Van der Kolk (1995) is that, in general, improving upon one dimension may have a weakening effect on another. To signify the difficult trade-offs that sometimes have to be made they refer to their model as the *devil’s quadrangle*.

It is important to create awareness about this trade-off at the companies that want to improve their business when they are setting their project goals. The application of a certain BI method may result in an improving effect on one dimension and at the same time a worsening effect on another dimension.
7.3.2. Expected Pay-off of Method

The paradigm of expected pay-off presents the adoption of BI methods according to the managers’ expectations of and desire for potential pay-offs. Consultants disseminate a BI method and suggest the promised benefits attached to the method. The expected pay-off is one of the key decision criteria, when management wishes to make a rational choice between improvement initiatives.

Porter (1996) clearly distinguishes between operational effectiveness and strategic positioning. Although the improvement resulting from applying BI methods have often been dramatic, many companies have been frustrated by their inability to translate those gains into sustainable profitability (Porter, 1996). Operational effectiveness and strategic positioning are both essential to superior performance, which is the primary goal of any enterprise.

A company can outperform rivals only if it can establish a difference that it can preserve. It must deliver greater value to customers or create comparable value at a lower cost (customer value). “The arithmetic of superior profitability then follows: delivering greater value allows a company to charge higher average unit prices; greater efficiency results in lower average unit costs” (Porter, 1996, p.4). Ultimately, all differences between companies in cost or price derive from the activities required to create, produce, sell, and deliver their products or services.

Operational effectiveness (OE) means performing similar activities better than rivals performs them. Operational effectiveness refers to any number of practices that allow a company to better utilize its inputs. In contrast, strategic positioning means performing different activities from rivals or performing similar activities in different ways. Differences in operational effectiveness among companies are pervasive. Some companies are able to get more out of their inputs than others because they eliminate wasted effort, employ more advanced technology, motivate employees better, or have greater insight into managing a particular set of activities.

Constant improvement in operational effectiveness is necessary to achieve superior profitability. However, it is usually not sufficient. Few companies have competed successfully on the basis of operational effectiveness over an extended period, and staying ahead of rivals gets harder every day. The most obvious reason for that is the rapid diffusion of best practices. Competitors can quickly imitate management techniques, new technologies, and superior ways of meeting customers’ needs. The most generic solutions diffuse the fastest. The second reason that improved OE is insufficient is more subtle and insidious. The more benchmarking companies do, the more they look alike. The more that rivals outsource activities to efficient third parties, often the same ones, the more generic those activities become. As rivals imitate one another’s improvements in quality, cycle times, or supplier partnerships, strategies converge and competition becomes a series of races down identical paths that no one can win.

Competitive strategy is about being different. It means deliberately choosing a different set of activities to deliver a unique mix of value. The essence of strategy is choosing to perform activities differently than rivals do. Otherwise, a strategy is nothing more than a marketing slogan that will not withstand competition.
The expected pay-off can be reached by concentrating on operational effectiveness, strategic positioning or a combination of both in order to complement to the existing strategic focus. This means that a company that already has a strong strategic positioning should choose a BI method that concentrates on improving the OE, to ultimately reach sustainable profitability. These classifications will be used later in this chapter to determine the numerical values of the expected pay-off of each BI method. In the next chapter, the last influential criterion in the scoring model (Popularity) will be explained.

7.3.3. Popularity of BI Methods
For decades, there has been a discussion on the application of management fads in the research field of BI methods by academics. The area of business improvement is particularly prone to the emergence of management fads. A management fad is considered as a relatively transitory managerial discourse on a particular concept and organizational changes induced by, and associated with this discourse (Benders and van Veen, 2001). In this section, quantitative evidence of the trends of academic and management discourse on these themes is presented, based on the annual publication numbers for the five different BI methods selected.

7.3.3.1. Introduction
BI methods have been propagated by ‘fashion setters’ originating from the consulting industry. These methods commonly claim to be a solution to most of the present-day organizational problems (Fincham and Roslender, 2003). Newly introduced BI methods are launched as novel, promising ideas that will bring significant performance improvements. According to Heusinkveld and Benders (2001) there are two main aspects when fashion setters seek to introduce a new management fad. First, it is suggested that there exists a dramatic gap in performance between ‘advanced’ and ‘ordinary’ organizations (Abrahamson, 1997). The survival of a company is threatened if they continue working in their accustomed way. Second, the fad is presented as a rational, progressive cure-all for the performance gap, so that implementing the concept can be seen as a rational act leading progress. By referring to successful applications in prominent organizations they are portrayed as a beneficial and legitimate solution. These arguments impel companies to apply popular BI methods to their improvement projects.

Managers are continuously confronted with persistent and complex organizational problems. As certain BI methods gain in popularity these managers feel compelled to apply these BI methods to their current organizational problems. This is an irrational influence, as choosing for a popular method may not be the best fitting BI method to a particular improvement project. However, we will take the popularity into account in the design of our DST as we could conclude from our interviews that a consultant’s selection process is influenced by popularity (Appendix G). Nevertheless, Staw and Epstein (2000) claim that adopting a newly BI method without fully understanding the capabilities of the method can cause problems to organizations. In this way, consultants will not be able to exploit the full potential of certain BI methods and will not be able to act upon the true needs of the organization considered to change.

In most cases, popular concepts eventually become criticized if the initially promised performance improvements are not reached by the application of the BI methods to specific improvement projects within organizations. As a consequence, the reception patterns of a specific BI method within businesses show a transitory character in which a period of uncritical euphoria is quickly followed by a phase of
disillusionment (Gill and Whittle, 1993; Abrahamson and Fairchild, 1999). Therefore the popularity of BI methods has frequently been pictured as a bell-shaped curve. Based upon the theory of management fashion, a case study from literature (Peters and Heusinkveld, 2010) and interviews with Infosys we can claim that the popularity of a BI method is an influential criterion in the decision making.

7.3.3.2. Methodology
Research on BI methods’ incidence is costly and methodologically difficult (Benders et al., 2007). Also, given a concept’s interpretative viability and inherent vagueness (Benders and Van Veen, 2001; Giroux, 2006), constructing measurement instrument tends to be difficult and the result is likely to remain contentious. This contributes to the usage of an alternative methodology for studying the popularity of organization concepts: the use of ‘print media indicators’ (PMI).

PMI is a method widely used to obtain the popularity of BI methods (Benders et al., 2007). PMI refers to data of citation hits obtained from electronic databases, which can be used to investigate the lifecycle and popularity of management fashions. The method is based on the assumption that the number of publications on any selected topic reflects interest in the topic over a period of time (Benders et al., 2007).

The phenomenon of fashion adopters was investigated through a survey of company usage rate by Bain & Company (Bain & Company 2005). Seven management tools: TQM, BPR, Six Sigma, Benchmarking, Knowledge Management, Change Management, and Balanced Scorecard were selected for comparison between more than 7000 respondents. The linkage between fashion setters and fashion adopters was identified through quantitative and statistical analysis. This suggests that the usage of PMI is a method which is less time intensive and can still indicate a valid popularity of BI methods application in practice.

For our study we will use the online database ABI/Inform, because the search result uses multiple databases which contain more than two million documents. A comparison of ABI/Inform with alternatives such as Business Source Premier, Web of Science, Zetoc and Recent Advances in Manufacturing, showed that it covered a wider range of publications in the area of interest (Thawesaengskulthai, 2006). ABI/Inform’s database stores articles covering business-related topics from more than 2,000 professional, scholarly, trade, and general-interest periodicals. Another advantage of ABI/Inform is its advanced search function which allows users to limit the search results according to a specific data range, and keywords. The extracted data from ABI/Inform will not indicate research interest only – the publications counted include those in academic journals and articles in business publications, many of which were written by consultants and other practitioners. However, ABI/Inform is limited to English-written publications; hence the PMI data does not reflect non-English texts.

Although fashionable concepts are extensively propagated and transferred, the extent to which and the way they are received may be highly context-specific. Between countries notable variations in the popularity of a method have been studied (Benders and van Bijsterveld, 2000). However, for the design of this DST we do not distinguish between the popularity of BI methods between countries. This can be used in future research to tailor the tool to a specific country.
The search terms used for the five different methods with quotations marks can be found in Table 7. The search options selected were whether the search term could be found in the ‘citation and abstract’ or in the ‘citation and document text’. The researchers consider the fact that the concept’s label is mentioned in the citation, abstract or document text as independent variables (Barley et al., 1988) indicative of its popularity. We conducted the PMI method by specifying the publication date, ranging from 1 January to 31 December in a particular year. Data related to the period 1991-2010 was extracted in June 2011 (Appendix J). From 1991 on, ABI/Inform has the most of its articles in full-text available. A Microsoft Excel sheet has been used to compile the number of publications over the past nineteen years (1991-2010) and produce trend graphs. We are well aware that the total volume of academic and business publications have probably increased over the 19 year period considered. We have chosen not to include the acronyms of the BI methods as they may resemble other concepts than targeted for.

<table>
<thead>
<tr>
<th>TQM</th>
<th>Six Sigma</th>
<th>Lean</th>
<th>BPR</th>
<th>BPM</th>
</tr>
</thead>
</table>

Table 7. Input in Keyword Search

7.3.3.3. **Results**

From Figure 5 we can see the academic and business discourse through the non-accumulating number of publications for the five BI methods from 1991 to 2010. We can see for each of the BI methods that they have bell-shaped patterns, with noticeable peaks in different time zones. This shows that through the number of publications, some methods get abandoned in the managerial discourse after a certain amount of time and new methods become more popular. TQM and BPR are methods that rose sharply in popularity beginning 1990s and have been maturing from 1999 onwards. These concepts were still frequently mentioned in subsequent years, with the number of articles reaching a steady-state, indicating that these methods remain of interest to academia’s and practitioners.

![Print Media Indicators 1991-2010](image_url)
From the moment the number of publications of TQM and BPR declined, the number of publications in Lean, Six Sigma and BPM rose rapidly. All of these methods gained a huge amount of popularity from 1998 onwards. The number of publications has been declining for these three methods from 2005 onwards, but has not yet reached a steady-state yet. The graph clearly shows that Six Sigma is the BI method with the highest popularity in the managerial discourse among the different BI methods over the last decade. A consultant from IBM remarked that this may be a self-fulfilling prophecy as this method allows to be more discussed from a research perspective from its array of techniques and their statistical background. We can see that as Lean had a rapid increase in the number of publications between 2002 and 2004, so did Six Sigma. This may be due to the emergence of a new concept of integrating these two BI methods to apply at improvement projects (known as Lean Six Sigma). If the theory on management fashions is consistent with these trends graphs, in the coming years Lean, Six Sigma and BPM may mature and new management fashions may be born (Näslund, 2008).

A decline in the number of publications related to a particular BI method could have various origins, such as (Thawesaengskulthai, 2006):

1. The concept is mature, there is relatively little potential for new knowledge contribution
2. Outcomes from the approach are disappointing and do not match early expectations,
3. More effective (or at least newer) approaches have emerged.

As a result of any or all of the above, authors and editors will tend to lose interest and the number of publication will decline. The number of publications may be sustained, if researchers are still discoursing and contributing to the body of knowledge in the theme. Indeed, some articles emerge which reflect upon the decline of major fashions, thereby increasing citation hits in their declining years.

The popularity of the BI methods will be calculated by taking the number of publications for each method in 2010. The number of publications of a specific method is compared to the total number of publications by taking the percentages. These are graphically shown in Figure 6.

7.3.4. A Scoring Model based on Multi-criteria Decision Making

In this chapter the concept of Multi-criteria Decision Making will be explained in more detail. We will conclude at the end of this chapter that we need to compare the available scoring methods in MCDM. This is required in order to select the most applicable scoring method for this research. Moreover, the specific scoring model used in the DST will be elaborated complemented by screenshots of the technique in Excel in Appendix N2.
Usually an MCDM method aims at one of the following four goals (Roy, 1990):

1) Find the best alternative
2) Group the alternatives into well-defined classes
3) Rank the alternatives in order of total preference
4) Describe how well each alternative meets all the criteria simultaneously

In the case of decision making for BI Methods a ranking of the alternative methods will be provided in order of total preference. This will allow integration of preferred BI methods in an improvement project. This allows methods to be blended together in order to complement each other.

MCDM is divided into Multi-objective Decision Making (MODM) and Multi-attribute Decision Making (MADM). MODM studies decision problems in which the decision space is continuous. On the other hand, MADM concentrates on problems with discrete decision spaces. In these problems the set of decision alternatives has been predetermined. MADM is the type of decision making techniques where we will be concentrating on, as this research also considers a discrete decision space with predetermined decision alternatives (the different BI methods).

Each MADM problem is associated with multiple decision criteria, they represent the different dimensions from which the alternative decisions can be viewed. Different decision criteria can be associated with different units of measure, this nature makes MADM intrinsically hard to solve (Triantaphyllou et al., 1998). Most of the MADM methods require that the attributes be assigned weights of importance. Usually these weights are normalized to add up to one. An MADM problem can be easily expressed in matrix format as can be seen in the following definition.

**Definition 1.**

Let \( A = \{ A_i, \text{for } i = 1,2,3, ..., M \} \) be a finite set of decision alternative and let \( C = \{ C_j, \text{for } j = 1,2,3, ..., N \} \) be a finite set of criteria according to which the desirability of an action is judged. Furthermore, we assume that for each decision criteria the decision maker(s) can determine its weight of importance as \( W = \{ W_j, \text{for } j = 1,2,3, ..., N \} \). The \( a_{ij} \) element of a decision matrix represent the performance value of the \( i \)-th alternative in terms of the \( j \)-th decision criterion.

This definition allows us to design a typical decision matrix \((M \times N)\) as in Figure 7.

![Figure 7. A typical decision matrix (Triantaphyllou et al., 1998)](image-url)
A hypothetical example on how MADM can work for purchasing a new car is provided in Appendix K. This example clearly shows that there is a high subjective influence in the determination of the $a_{ij}$ and $W_j$ values by the decision maker, where we have to remain aware of during our design. The performance value ($a_{ij}$) of a decision criterion is influenced by the given weight of importance of that criterion ($W_j$).

From the early developments of the MADM theories in the 1950s, a plethora of MCDA methods have been developed in the literature and new contributions are continuously coming forth in this area. The most widely used classification for MADM methods is to the type of data which can be deterministic, stochastic or fuzzy (Triantaphyllou, 2000). For this research we assume to have deterministic data for the $a_{ij}$ and $W_j$ values. Triantaphyllou and Baig (2004) show that the Weighted Sum Model (WSM), the Weighted Product Model (WPM), the Analytical Hierarchy Process (AHP) and the Revised Analytical Hierarchy Process are the most widely applied methods within deterministic MADM. In the next chapter these methods will be compared to pick the most suitable method for this research.

### 7.3.5. Multi-Attribute Decision Making Methods

In this chapter we will be comparing the most widely used MADM methods: WSM, WPM, AHP and the Revised AHP to discover the strengths and weaknesses of these methods and their overall fit to this research. This chapter will focus on the question: "What is the most appropriate model to use in the decision supporting technique for selecting a BI method at an improvement project?".

From our analysis on MADM models we could conclude the following. WSM only works on single-dimensional analyses, this does not apply to this research where we have criteria with different dimensions being taken into consideration simultaneously. Moreover, AHP and both the revised AHP have received some criticism from literature with regard to their performance and consistency in ranking when new alternatives are added to the existing set of alternatives (Triantaphyllou, 2000). Another important drawback of AHP is that it starts with the assumption that no relationship between decision criteria of the same hierarchical level is allowed. In real situations, decision criteria on the same level do interact with each other. Belton and Gear (1983) proposed a revised version of the AHP model, as an inconsistency in ranking of alternatives can occur when an identical alternative to one of the nonoptimal alternatives is introduced. However, according to Triantaphyllou (2000) this does not solve the criticism from literature with regard to their consistency in ranking when new alternatives are added to the existing set of alternatives. As we are focusing on a DST that can be extended with other BI methods it is not an option to select AHP or the revised AHP scoring models to this research.

For the decision problem of selecting the best alternative or ranking the alternatives when conflicting (i.e. “benefit” and “cost”) criteria are present, it could make a big difference if any of the additive MADM methods are used (i.e. WSM, AHP and revised AHP). The WPM is immune to any ranking reversals as this method yields identical results (Triantaphyllou and Baig, 2004). This does however not prove that WPM is a perfect MADM method, but this consistency in its ranking is to its credit. The WPM seems most applicable to this MCDM problem as criteria with different dimensions will be used in ranking the BI Methods. In Appendix L the different models and their mathematical equations are explained in more detail. In Appendix M there is an example used based on Triantaphyllou et al. (1998) to show how to use...
these methods and their mathematical equations can be applied. In the next chapter WPM’s mathematical model and its application will be explained.

7.3.6. The Weighted Product Model
Each decision alternative is compared with the others by multiplying a number of ratios, one for each criterion. Each ration is raised to the power equivalent to the relative weight of the corresponding criterion. In general, in order to compare the alternatives \( A_K \) and \( A_L \) (denoted as \( A_K/A_L \) ) a ratio \( R(A_K/A_L) \) (Miller and Starr, 1969) has to be calculated:

\[
R \left( \frac{A_K}{A_L} \right) = \prod_{j=1}^{N} (a_{Kj}/a_{Lj})^{w_j}
\]  

(1)

If the term \( R \left( \frac{A_K}{A_L} \right) \) is greater than one, the alternative \( A_K \) is more desirable than alternative \( A_L \). The best alternative is the one that is better than or at least equal to all the other alternatives. The WPM is sometimes called the dimensionless analysis because its structure eliminates any units of measure. Thus, the WPM can be used in single- and multi-dimensional decision-making problems.

7.3.7. Scoring Model Implementation in DST
In this chapter the WPM model and the classified criteria will be blended together and used in the second phase of the DST. The remaining subjects cover attaching numerical measures to the relative importance of the criteria and to the impacts of the alternatives on these criteria. Subsequently, the numerical values to determine a pre-defined goal of the analysis will be determined.

The weights to be assigned to the importance of each criterion to the company are a value between 0% and 100% where the sum of the weights should add up to 100%. This method is called Point Allocation and is very easy to use and has high trust worthiness (Canez, 2000).

The criteria should be rated to measure how well each BI method achieves on each of the defined criteria. Moreover, the company should provide a score where they would like to aim their improvement project on. The Likert scale is most suitable for rating the criteria for this purpose (Yoon and Hwang, 1995). The scores should be provided for the Project-based criteria by the company. These scores give an indication on which of the sub-criteria the company wants to aim for improving in their improvement project. For instance, if a company wants to focus on Quality in their Project goals-criterion then a higher score can be dedicated to that sub-criterion. The score range is [1-10], where 1 is a very low achievement on a particular sub-criterion and 10 is a very high achievement on a particular sub-criterion. The maximum amount of points to be dedicated to each criterion is calculated as follows:

\[
SUM(C_j) = \left( \frac{N_j}{2} \right) \times 10
\]  

(2)
$N_j$ is the number of sub-criteria within a criterion. Project Goals has four different sub-criteria (Time, Cost, Flexibility and Quality). Expected Pay-off has two different sub criteria (Operational Effectiveness and Strategic Positioning). This leads to the following calculations

\[
SUM(C_1) = \left( \frac{4}{2} \times 10 \right) = 20 \tag{2.1}
\]

\[
SUM(C_2) = \left( \frac{2}{2} \times 10 \right) = 10 \tag{2.2}
\]

Therefore 20 points and 10 points can be dedicated to Project Goals and Expected Pay-off respectively. These maximum amount of points resemble the trade-offs between the criteria as earlier explained (e.g. the devil’s quadrangle in Project Goals).

The next step is that the scores are determined for each BI method of the influence on each sub-criterion. Moreover, we have adapted the decision matrix (see Table 8), where we include an extra alternative. This extra alternative is the company’s aim scores on all the defined criteria related to their specific improvement project, denoted as $A_c$. This allows us to calculate ratios of each BI method compared to the aim scores of a company with an improvement project. If we would not have inserted this extra alternative, then the ranking would not be compared to the project-related characteristics of the improvement project of a company. Each decision maker that wants to use the score model has to fill in only the yellow cells of the decision matrix (Table 8).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Project goals</th>
<th>Expected Pay-off</th>
<th>Popularity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weights</td>
<td>$W_1$</td>
<td>$W_2$</td>
<td>$W_3$</td>
</tr>
<tr>
<td>Sub-criteria</td>
<td>Time</td>
<td>Cost</td>
<td>Flexibility</td>
</tr>
<tr>
<td>Sub-weights</td>
<td>$w_{11}$</td>
<td>$w_{12}$</td>
<td>$w_{13}$</td>
</tr>
<tr>
<td>$A_c$ (TQM)</td>
<td>$a_{c1}$</td>
<td>$a_{c2}$</td>
<td>$a_{c3}$</td>
</tr>
<tr>
<td>$A_2$ (Six Sigma)</td>
<td>2</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>$A_3$ (Lean)</td>
<td>8</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>$A_4$ (BPR)</td>
<td>7</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>$A_5$ (BPM)</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 8. Decision Matrix of Selection of BI Methods

$w_j$ represents the weight of each sub-criterion which is calculated as the total weight per criterion divided by the number of sub-criteria ($N_j$).

\[
w_j = \frac{W_j}{N_j} \tag{4}
\]

E.g. if we allocate a weight of 80% to the criterion Project goals, then the formula is filled in as follows for the sub-weight of the sub-criterion Time:

\[
w_{11} = \frac{w_{11}}{N_1} = \frac{0.8}{4} = 0.2 \tag{4.1}
\]
This means that the sub-criterion Time gets a weight allocated of 20%. Note that the other three decision criteria of Project Goals will get the same sub-weight allocated.

The scores within the decision matrix for the alternative BI methods have been estimated together with consultants who have expertise in specific methods from Infosys Consulting. Moreover, the scores will be compared to the scores provided by Thawesaengskulthai (2006), who did a comparable study concerning TQM, Six Sigma, Lean and BPR. We have to remain aware that the scores of the BI methods represent averages. These scores are highly dependent on which range of techniques from the BI method are applied in the improvement project. For example, different best practices of BPM may result in different scores with regard to project goals (Limam Mansar & Reijers, 2005). The scores of the popularity of the BI methods have been determined from Chapter 7.3.3. based upon the PMIs. When we have five different BI methods a normal popularity of a method would be resembled by 20% of the total amount of publications in 2010. Therefore the ratio is calculated between the percentages of publications from each BI method in 2010 compared to the normal popularity of a BI method (20%).

One of the most crucial steps in many decision making methods is the accurate estimation of the appropriate data. This problem is particularly crucial in our research which needs to elicit qualitative information from the decision maker. Qualitative data can be very difficult to transform into quantitative measures, which are necessary for MADM. MADM still involves a certain element of subjectivity, therefore the ethics of the persons using MCDM play a significant part in the accuracy and fairness of the conclusions that can be drawn from the DST.

As mentioned earlier, the formula of WPM (1) will allow us to compare the company aim score \(A_c\) against the different BI methods \(A_1 - A_5\). The formula will allow all the methods to get a ratio in comparison to the companies’ aim scores. For instance, the ratio between the company’s aim score and TQM’s score, based on formula (1), will then be:

\[
R \left( \frac{A_c}{A_1} \right) = \prod_{j=1}^{5} \left( \frac{a_{c,j}}{a_{1,j}} \right)^{w_j}
\]

Subsequently, the ratios will be calculated for the other pre-selected BI methods. If the ratio is 1, then the scores of the BI method are the same as the aim scores of the company. If the ratio is smaller than 1, then the scores of the BI method are higher than the aim scores of the company and the BI method will be favorable. Therefore, the advice will be to take a closer look at the BI methods which have a score which is equal to or lower than 1, denoted as follows:

\[
R \left( \frac{A_c}{A_L} \right) \leq 1
\]

Moreover, the method’s ranks will be put in ascending order to create visibility on the most effective BI method. This score of the possible selected BI methods should be input for further discussions among consultants and other decision makers rather as seeing it as a final answer.
### 7.4. Phase 3: Sensitivity Analysis

Sensitivity analysis is a fundamental concept for the effective use of quantitative decision models (Dantzig, 1963). The data input of the weights of the criteria is subjective and may be imprecise. Therefore an important step in many applications of MCDM is to perform an analysis regarding the score robustness of the input data. Moreover, we can provide graphs which display the scores of a BI method that do not match with the company aim scores, both on the level of criteria (bar chart) and sub-criteria (radar chart or spider web chart). The screenshots for this phase of the DST can be found in Appendix N3. The score robustness calculation will now be explained.

#### 7.4.1. Score Robustness

This chapter presents the methodology for performing our sensitivity analysis on the weights of the decision criteria. The objectives of a sensitivity analysis of an MCDM problem is to find out when the weights \( w_j \) are changed into new values, how the ranking of the alternatives will change. Triantaphyllou and Sánchez (1997) proposed an approach for a sensitivity analysis for the WPM model.

The decision maker is interested in the switchover point; this is the point at which the parameters produce the break-even point. If a high relative change is required to a weight to produce the break-even point, this is called a remote switchover point. However, a clear definition of a remote switchover point is subjective to what a decision maker defines as a high relative change. If the analysis shows that we have remote switchover points, then the decision maker can be confident of the validity of the current results. We assume then that for each criterion \( C_j \), the decision maker has determined its importance, or weight, \( W_j \). It is also assumed that the following relationship is always true:

\[
\sum_{j=1}^{N} W_j = 1
\]  

(7)

**Definition 2.**

\( K \) is the relative change by which the current weight \( W_k \) of criterion \( C_k \) needs to be modified so that the ranking of the company’s aim \( A_c \) and one of the BI methods \( A_1 - A_5 \) will be reversed, is given as follows (proof can be found in Triantaphyllou and Sánchez, 1997, p.43):

\[
K = \frac{\log(\prod_{j=1}^{N} (a_{cj}/a_{ij})^{w_j})}{\log(a_{ck}/a_{ik})} \times \frac{100}{W_k}
\]

(8a)

subject to: \( K \leq 100 \)  

(8b)

E.g., this will mean the following if we want to calculate the score for the criterion Project Goals for the BI method TQM.

\[
K_{TQM} = \frac{\log(\text{Total score(TQM)})}{\log(\text{Project Goals score(TQM)})} \times \frac{100}{W_{Project Goals}}
\]

(9)
Phase 3. Theory Testing
This phase describes how the decision support technique has been evaluated and redesigned. The redesign recommendations on our selection framework are also dealt with.

8. Evaluation
In the testing phase, the proposed selection framework and DST were empirically tested two times. We have evaluated the developed framework and DST in three steps from a consultant’s perspective. Ultimately, the consultants are targeted to be the users of the framework and DST. The first evaluation took place at Infosys with Indian consultants (in April 2011), from where we redesigned the selection framework and DST. Thereafter the second evaluation session took place with Dutch consultants from both IBM and Deloitte. After this last evaluation, the final designs for the selection framework and DST have been made, which were presented in this paper.

8.1. Methodology for Evaluation
The consultants that participated for this evaluation on behalf of Infosys, Deloitte and IBM can be found in Appendix O. The goal of this evaluation was to verify and validate the framework and DST. Both evaluation sessions have been done by a case study where a fictive company wants to improve a business process (Appendix P). The fictional company and its problem statement have been based on a research by van Twillert (2007) on waste management in the Costa Rican construction sector. In this research, the company chooses to apply Lean to their improvement project. However, this is not considered to be the only possible BI method that can be applied to this problem. The aim of introducing a case study is to show how the DST can be used and to open a discussion on the understandability, usability, adaptability and traceability of the technique (Little, 1970). We tried to plan workshop sessions where consultants could provide the evaluation in a group. This stimulates the richness of information as discussion can take place between consultants. However, it was only possible to schedule the evaluations with seven consultants of Infosys and the five consultants of IBM in workshop sessions. The other evaluations (five with Infosys and three with Deloitte) took place individually with the researcher. The researcher operated as facilitator during the evaluations and tried to guide and structure the process. The facilitator limited its influence by explaining the concepts and models used and did not attempt to influence the participating consultants’ views. The evaluation guide used by the consultants throughout the process can be found in Appendix Q. After the evaluations, the consultants were offered an evaluation form (Appendix R). However, due to time constraints we only received three filled in evaluation forms of the twelve evaluators in our first evaluation session and is therefore not used in this analysis. The process depicted took place during the evaluation:
8.2. Redesign of the Selection Framework

The consultants from Infosys had some minor design recommendations regarding the selection framework. The steps that were described in the framework overlapped with steps from their proprietary framework (Impact). The supplementing steps from literature were all accepted well. They suggested extending the framework by introducing the Barriers to start and Critical Success Factors, for which the researcher used the publications of Thawesaengskulthai (2006) to describe the concepts. After a redesign of the framework, it was perceived with great enthusiasm by Vivek (Partner of Infosys Consulting, Indian Markets) and is now used in the curricula of training programs for junior consultants to understand the selection process of BI methods at improvement projects. This allows them to understand the crucial steps in the reasoning of senior consultants during an improvement project.

The consultants from IBM and Deloitte barely had any comments on the redesigned framework. They only had minor recommendations on words used in the framework which could be confusing. Moreover, two consultants of Deloitte suggested that sometimes a consulting firm can already be contracted at an earlier stage of the improvement project and will help to set the preconditions for improvement (Step 3), such as the project scope, budget and project goals. When this scenario applies, Step 3 and Step 4 (Understand the environment) will take place in parallel. However, this has been explained to be an exception to the formal process at which the selection of BI methods normally takes place. Therefore this redesign has not been considered for our final design. IBM consultants proposed to supplement the selection framework by describing the two main forces that play a role in the selection process from a consultant’s point of view (Capability push) and a company’s point of view (Demand pull) (Chapter 6.2).

The overall impression gained from the consultants was that the selection framework was very useful in providing a structured and holistic view of the selection process and positioning the use of the DST.

8.3. Redesign of the Decision Support Technique

Feedback on the application of the DST was obtained through discussions with the participants and reflections from observation in the evaluation sessions. The criteria in the elimination-based phase and the scoring model were argued to cover a lot of important factors that play a role in the selection of BI methods in an improvement project. We will elaborate the findings of the evaluation session based on the understandability, usability, adaptability and traceability of the technique (Little, 1970).

Understandability: There was a big issue regarding the understandability of the criteria Project Goals and Expected Pay-off which were argued not to be mutually exclusive. The classification of Expected Pay-off, as it was initially defined by Thawesaengskulthai (2006), had too much overlap with the classification of Project Goals by Brand and van der Kolk (1995). In the first design, Expected pay-off was classified with seven variables: Shareholder benefits, Company performance, Market performance, Customer satisfaction, Human Resources, Process Improvement and Organizational benefits (Thawesaengskulthai, 2006). The suggested benefits of each of these variables can be found in Appendix S.

In our first redesign of the DST (Table 9), we reclassified the Expected Pay-off, by eliminating not directly related variables to the application of a BI method to an improvement project (‘Shareholder benefits’ and ‘Company performance’). We combined ‘Market performance’ and ‘Customer Satisfaction’ to one
new variable: ‘Customer Value’, as the definitions of these two variables was overlapping. Moreover, we renamed the two variables, which were concerned to be ambiguous. The variable ‘Human Resources’ was changed to ‘Working Capital’ as its definition concerns with the reduction of the number of resources used and an increase in employees’ skills. ‘Organizational benefits’ was renamed to ‘Organizational improvement program’ as its definition concerned the creation of an agile and learning organizational improvement culture.

<table>
<thead>
<tr>
<th>First redesign recommendations Expected Pay-off</th>
<th>No. of participants mentioning the required redesign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliminate ‘Shareholder benefits’</td>
<td>7 of 12</td>
</tr>
<tr>
<td>Eliminate ‘Company performance’</td>
<td>7 of 12</td>
</tr>
<tr>
<td>Combine ‘Market performance’ and ‘Customer Satisfaction’</td>
<td>7 of 12</td>
</tr>
<tr>
<td>Rename ‘Human Resources’</td>
<td>5 of 12</td>
</tr>
<tr>
<td>Rename ‘Organizational benefits’</td>
<td>5 of 12</td>
</tr>
</tbody>
</table>

*Table 9. Redesign recommendations for Expected Pay-off*

The classification of Expected Pay-off then became:

- Customer Value
- Working Capital
- Process Improvement
- Organizational Improvement Program

Our second evaluation session with IBM and Deloitte, the classification of Expected Pay-off was still not considered to be satisfying by 6 of 8 consultants. We then adapted the classification by using a publication from Porter (1996), suggested by the five consultants of IBM, which is considered to be mutually exclusive.

In both evaluation sessions all the consultants understood the definitions and classifications of the other criteria in the DST. The three distinct phases in the DST and their functionalities were also understood by all consultants. Although the researcher observed that the steps in the DST were quite easy to follow by all consultants, they still needed to ask for a lot of help by the facilitator. By introducing ‘help boxes’ (suggested by a consultant from Infosys) in each separate worksheet we tried to guide the consultants and decrease the help they needed to ask to the facilitator. A consultant of IBM suggested providing the definitions of the criteria, when the cells of the criteria are selected in the DST. An example of these redesigns can be found in Appendix N2.

**Usability:** There were a lot of suggestions throughout the evaluation sessions on improving the look and lay-out of the DST. From the first evaluation session, six consultants proposed to use different colors in the DST to easily see which cells need input in order for the DST to come with a ranking of the BI methods. The following redesigns were made regarding the use of colors:

- Only yellow cells have to be filled in by the user of the DST, as can be seen in Appendix N.
- The help boxes have an orange color and would be placed at the bottom of each separate worksheet.
- BI methods that were selected from the first phase would remain in a green column.
- If a BI method was not selected in the first phase, it would be placed in a red column.
The researcher proposed to use ‘Data Validation’ after the first evaluation session to increase the usability of the DST. Data Validation is an Excel feature that can be used to define restrictions on what data can be entered in a cell. This allows us preventing users from entering data that is not valid. We restricted users to allow input only to predefined items in a list. These lists are defined in the separate worksheet ‘Categories Classification’. By leaving an extra blank line in the list, the cell will be blank in default. Moreover, we also provided messages to define what input we expect for each cell.

In both evaluation sessions, a total of six consultants proposed to protect the workbook elements. This prevents a user from accidentally or deliberately changing, moving, or deleting important data from a workbook. However, we have chosen not to protect the workbook as it is still under development and should be easily adapted. We suggest using a protection of worksheet elements once it is applied to the consulting industry. In this way, users of the DST will not be able to make any changes to a locked cell. Only the yellow cells in the DST should be allowed to change, as these are the cells which require input.

**Adaptability and Traceability**: The adaptability was improved after the first redesign by introducing predefined lists with items of input data. The introduction of help boxes allowed the user to clearly see what was required to do at each phase in order to get a rank of BI methods. The facilitator could show how the output was derived from the formulas in the Excel worksheets, which were understood by all consultants. This allowed the consultants to trace down how certain output was obtained and could be adapted.

The consultants of Infosys were already involved in the initial design of the DST. This allowed them to look into more depth how the ranking is derived from the input in the evaluation sessions. In the first evaluation session, the DST showed to have a good traceability which allowed eight of twelve consultants to look at the elimination factors (Phase 1) and scores of BI methods (Phase 2). After the first evaluation session, we adapted the following elimination factors and scores as depicted in Table 10.

<table>
<thead>
<tr>
<th>Recommendation regarding elimination factors or scores</th>
<th>Claim</th>
<th>No. of consultants that made the claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elimination factors</td>
<td>Lean should not be eliminated when the Industries HC, FI or IT is selected</td>
<td>6 of 8</td>
</tr>
<tr>
<td>Elimination factors</td>
<td>BPM should not be eliminated when the Industry MA is selected</td>
<td>4 of 8</td>
</tr>
<tr>
<td>Scores</td>
<td>Lean’s score to Project Goals should be altered. (Time 6→8, Quality 4→2)</td>
<td>2 of 8</td>
</tr>
<tr>
<td>Scores</td>
<td>Six Sigma’s score to Project Goals should be altered. (Cost 8→9, Quality 8→7)</td>
<td>4 of 8</td>
</tr>
</tbody>
</table>

*Table 10. Redesign Recommendations of DST*

In the second evaluation session, the consultants from IBM and Deloitte required more time to understand, use and adapt the DST. This did not allow them to trace down how the DST came to its ranking within the time available during the evaluation sessions. Therefore, no recommendations regarding elimination factors or scores were given during the second evaluation session. The sensitivity
analysis provided more insights into the validity of the ranking given by the DST, but this was applied to the DST after the evaluation sessions were held.

8.4. Conclusions

The main strength of the DST is that it allows consultants to make a selection of BI methods which can be applied to an improvement project based upon both organizational characteristics and project-related characteristics. Moreover, the DST promotes senior consultants to keep a broad perspective in selecting their preferred BI method(s). The framework and DST try to bring objectivity into the decision making process and have a defined logic. All participants agreed that the framework and DST provide comprehensive selection processes which cover a lot of influential criteria for the selection of BI methods. However, they emphasized that the DST should be used as a supporting technique and cannot control the decision making process.

The consultants in both evaluation sessions showed to be able to understand, use and adapt the DST. However, all the consultants still needed help from the facilitator on how to fill in the DST, but once this was explained they could all understand the reasoning behind the design of the DST. During the second evaluation session, all consultants were not able to derive how the DST came to its ranking. The consultants of the first evaluation session had less trouble with this issue, where eight out of twelve consultants made recommendations regarding elimination factors and scores in the DST. This difference can be explained as the consultants in the first evaluation session were involved in the design phase of the DST. The consultants from IBM and Deloitte required more time to understand the concept behind the DST, which did not provide them with enough time to provide redesign recommendations regarding elimination factors and scores of the BI methods.

A weakness of the DST is that the accuracy of the scoring model is based upon the accuracy of the scores provided for each BI method. In future research, these scores should be validated as only eight of the twenty consultants had a chance to critically look at the scores in our evaluation sessions. Consultants (four from Infosys, two from IBM and two from Deloitte) suggested to improve the validity of eliminations and scores by using simulated data of past successful improvement projects. Two consultants from Infosys recommended designing a DST on the level of best practices and techniques of the specific BI methods. This allows a consultant to provide a best of breed of tailored solution from the different selected BI methods.

Consulting firms are nowadays looking for techniques and tools which allow accurate decision making and strengthening a proposal for a company with an improvement project. The DST allows consultants to keep a broad perspective in the selection of BI methods to apply on an improvement project. From the evaluation session we can conclude that the selection framework can be used in today’s decision making to position the use of a DST and guide the selection process of BI methods. The DST will require some redesigns based on historic cases to improve the accuracy of the scoring model, but provides good means for supporting, justifying and rationalizing the decision making regarding the selection of BI methods.
9. Discussion and Conclusion

This research examines how consultants should select Business Improvement (BI) methods in an improvement project. Today’s competitive environment makes this selection a very relevant field of research. Currently, selection decisions are rarely structured and the selection criteria are intangible, inconsistent and may vary between consultants. Hence, today’s selection of BI methods to apply in an improvement project is based on ambiguous judgments and is prone to follow methods where consultants are acquainted with through their years of experience. It is important for consultants to take a broad perspective with regard to the selection of BI methods. Consultants in an improvement project will not be able to exploit the potential of other BI methods which they have not considered in their decision making process. Ultimately, consultants will then not be able to act upon the true needs of the organization considered to change.

This research aimed to fill the existing research gap by exploring the practices in improvement projects from a consultant’s perspective. From our literature review we could conclude that BI methods have a lot of similarities, but their main objectives are very different. Selecting a BI method with a different objective than the objective of a company’s improvement project will lead to not acting upon the true needs of an organization considered to change. Relevant selection criteria in the decision making process have been identified and validated and a Decision Support Technique (DST) has been developed, designed and tested in a consulting environment. The DST has been positioned in a selection framework, which describes the process of selecting BI methods. This chapter summarizes and discusses the knowledge gained from this research and identifies key areas for further research on this topic.

9.1. Research Findings

The research’s objective was to answer the following main research question:

*How can the selection of BI methods to be applied in an improvement project be rationalized, supported and justified?*

Through an extensive research, from both a rigorous and a relevant viewpoint, we were able to develop, design and test a DST for selecting BI methods at an improvement project. A selection framework was build to assist consultants to systematically follow a process map to choose the most suitable BI method(s) for a company. The main goal of this selection framework was to position the applicability of the DST within the selection process. Moreover, this research revealed some of the biases that take place in the selection process, both from the perspective of a consultant and a company with an improvement project. The DST provides means for eliminating and ranking BI methods for a specific improvement project based upon the characteristics of the improvement project, the organizational characteristics and external forces from outside the company.

Subsequently, the sub research questions posed in Chapter 1 will be answered.

- *What influential factors are currently analyzed by consultants to determine the best fitting BI method in a specific improvement project?*
There is a wide range of influential factors which are studied by consultants, although every consultant has their preferences. From the literature review we could formulate a list of influential factors (Chapter 2.4) from which we distilled the most relevant factors during interviews with consultants from Infosys (Chapter 6.5). We categorized these factors into three main drivers: (1) Project-based, (2) Internal Environment and (3) External Environment.

- **How large is the influence of irrational factors on the decision making process of practitioners concerning the selection of BI methods?**

There are certainly biases in the selection process both from a consultant’s perspective as from the perspective of a company with an improvement project. However we should not be concerned of the magnitude of these biases as consultants selected more rational factors (project-based and internal environment) than irrational factors (external environment) influencing the selection of BI methods.

- **Given the irrational influence on the decision making process, is it still possible and valuable to develop a rationalizing decision making technique?**

The important issue with irrational influences is to create awareness of their existence. This will diminish their influence in the decision making process. This research should definitely be a reminder to all decision makers about the possible biases in the decision making process. The designed selection framework and DST are aimed to provide consultants with an open mind when selecting a BI method and to not only think within their toolbox of most acquainted BI methods and techniques.

- **What influential rational factors should be captured in a decision support technique to be able to make a selection of suitable BI methods in a specific improvement project?**

The most influential factors that are captured in our DST are:

- Project Based: (1) Project Goals, (2) Expected pay-off of method
- Internal Environment: (3) The company industry, (4) Process Maturity Level, (5) Value proposition
- External Environment: (6) Popularity of the method

- **How can a framework be designed to explain the selection process of BI methods and position the use of a decision support technique in this process?**

Both academic rigor and practical relevance were used to design the selection framework which can be used to support the selection of BI methods. The framework is presented and explained in more detail in Chapter 4. The design of the framework was formed by two academic publications and a proprietary framework from Infosys Consulting. The design clearly shows that when the BI methods relevant to an improvement project are identified, the DST should be applied together with an individual assessment of decision makers. The framework was redesigned according to evaluation sessions with Indian and Dutch Consultants from Infosys, IBM and Deloitte.

- **How can a decision support technique be designed which should rationalize, support and justify the decision making process in the selection of BI methods?**
The DST is based upon three phases. These phases have been developed by the combination of decision models available in the academic literature and the interviews with consultants from Infosys. The first phase of the DST is a phase where we use an elimination-based approach. Based on the organizational characteristics and context, some BI methods will be eliminated from selection. The second phase of the DST uses a scoring model to provide the consultants with a ranking of the best alternatives of the set of alternatives selected from Phase 1. This will allow the best scoring alternatives to be integrated when selecting the most suitable BI methods for a specific improvement project. The third phase of the DST will provide a sensitivity analysis. It is important for the DST to provide a sensitivity analysis to increase the understandability of the influence of quantifying qualitative data to the decision maker and to provide traceability of where the ranking of alternatives is based upon. These three phases combined rationalize decision making as it is now structured and tangible which criteria influence the decision making. They support the decision maker by providing a broad perspective of BI methods which could be taken into consideration in the selection process. We design a technique in which the number of BI methods can be changed and extended. The DST can justify individual assessments on the selection of BI methods and can be used to improve the objectivity in the selection process of BI methods.

9.2. Limitations

After this research has been carried out, we take this chapter to reflect on our project from a scientific and practical perspective.

The deliverables of this project have been developed in both the Netherlands and India. By involving three multinational consulting firms (Infosys, IBM and Deloitte) we were able to design models that are applicable across regions. However, we only had the chance to interview fifteen consultants from Infosys to build our initial design of the selection framework and DST upon. We targeted this to be twenty senior consultants (or of higher rank), but due to resource and time constraints we were not able to fulfill this target. Nevertheless, we can mention that after the results of the fifteen interviews were analyzed we could see a lot of observations re-occurring across interviews. Then we only had twelve consultants which ranked the influential criteria retrieved from literature. Although the sample size may not be big enough to draw significantly statistical conclusions, we did not observe to have missed out any relevant influential criteria from our evaluation sessions as no new influential criteria were mentioned during any of the interviews.

For the reliability of our research, we would have liked to use a single approach for the evaluation sessions. We liked to plan workshop sessions with approximately five consultants per session. This would increase the richness of information as discussion between consultants could take place. In practice, it worked out different and we had to plan some individual evaluations. The information obtained from these sessions was very relevant for our redesigns, but we could see that more information was obtained from workshop sessions. Moreover, due to time constraints we were not able to retrieve quantitative data from the evaluation sessions. We had developed an evaluation form (Appendix R) which enabled consultants to give scores to our DST regarding understandability, usability, adaptability and traceability. This would have helped us to see in quantitative terms which area points of improvement were needed for the redesigns of our DST.
As a last point, we would like to emphasize that the DST is based on several assumptions. The approach assumes that the preferences of a company and the strengths of BI methods can be quantified. Moreover, the main influential criteria are argued to have been identified and can be weighted in order to reduce the subjectivity of the decision. Hence, gathering more reliable information on historic cases is needed to assess the validity of the elimination factors and scores of the DST.

9.3. Areas for future work

The limitations outlined above suggested the following areas for future work.

- **Investigate the problem from the perspective of companies with improvement projects**

  The problem has been investigated mainly from the perspective of consultants. Although it was a rich source of information as all of them had been a decision maker in different improvement projects, they could only describe the way they perceived this problem from the perspective of a company with an improvement project. More research is needed on the influence of managers of companies in the decision making as some of them are already biased by choosing a BI method that have been recommended by colleagues or management books.

- **Gather more empirical evidence of the decision rules and scores within the DST**

  The fact that at the last evaluation session barely any modifications were required to the selection framework indicates that a good level of usability and validity has been reached. Nevertheless, the consultants obtained a critical view towards some of the decision rules (Elimination-based) and scores (Score model) that were dedicated to the BI methods in the DST. More empirical evidence is needed to enhance the confidence of practitioners in using the DST, before they will actually apply it to their daily operations. As discussed earlier, there is a gap in literature on the claims of exclusion of BI methods under certain organizational characteristics.

- **Codify, store and re-use knowledge regarding decision making from improvement projects**

  In the consulting industry, knowledge is the most significant resource in building and sustaining a competitive advantage (Schreyögg & Geiger, 2007). Knowledge, inherently, resides in individuals; knowledge sharing is one of the most important processes in determining a firm’s success. Unfortunately, knowledge sharing within organizations still appears to be the exception rather than the rule. Consultants do not take a uniform approach to managing knowledge. The consulting business employs two very different knowledge management strategies. In some firms, knowledge is carefully codified and stored in databases, where it can be accessed and used easily by anyone in the company (codification strategy). In other firms, knowledge is closely tied to the person who developed it and is shared mainly through direct person-to-person contacts (personalization strategy). The codification strategy opens up the possibility of achieving scale in knowledge reuse and thus of growing the business (Hansen et al., 1999). A codification strategy should also be applied to capture decision making in the consulting industry, with close attention to decision making regarding the selection of BI methods. This can be used to facilitate further testing and refinement of the DST in a broader context.
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## Appendix A: Glossary

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<th>Description</th>
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<tr>
<td>AHP</td>
<td>Analytic Hierarchy Process – A MCDM method for organizing and analyzing complex decisions (not applied in this research)</td>
</tr>
<tr>
<td>BI</td>
<td>Business Improvement</td>
</tr>
<tr>
<td>BPM</td>
<td>Business Process Management, one of the studied business improvement methods for this research</td>
</tr>
<tr>
<td>BPR</td>
<td>Business Process Reengineering, one of the studied business improvement methods for this research</td>
</tr>
<tr>
<td>CMM</td>
<td>Capability Maturity Model – a development model, when applied to software development processes, it allows an effective approach toward improving them</td>
</tr>
<tr>
<td>DSS</td>
<td>Decision Support Systems – a computer-based information system that supports organizational decision making</td>
</tr>
<tr>
<td>DST</td>
<td>Decision Support Technique – a technique that will support practitioners in taking decisions concerning the selection of business improvement methods</td>
</tr>
<tr>
<td>Infosys</td>
<td>Infosys Technologies Limited. The Indian company at which part of the graduation project was performed</td>
</tr>
<tr>
<td>MADM</td>
<td>Multi-attribute Decision Making – MCDM based on a discrete decision space (applied in this research)</td>
</tr>
<tr>
<td>MCDM/MCDA</td>
<td>Multi-criteria Decision Making/ Multi-criteria Decision Analysis – a research discipline aimed at supporting decision makers faced with making decisions between alternatives</td>
</tr>
<tr>
<td>MODM</td>
<td>Multi-objective Decision Making – MCDM based on a continuous decision space (not applied in this research)</td>
</tr>
<tr>
<td>PMI</td>
<td>Print Media Indicators – The number of publications on an organization concept in the course of time reflects managerial interest in this concept</td>
</tr>
<tr>
<td>RFP</td>
<td>Request for Proposal – An company with an improvement project will send out a document in which it requests consulting firms to come up with a proposal for their improvement project</td>
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<td>TQM</td>
<td>Total Quality Management, one of the studied business improvement methods for this research</td>
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<td>University of Technology Eindhoven</td>
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<tr>
<td>vPMM</td>
<td>Value-based Process Maturity Model – a model that allows practitioners to identify the capability of an organization to define, manage, measure and control their processes to use for process improvement (Chapter 7.2.3.)</td>
</tr>
<tr>
<td>WPM</td>
<td>A MCDM method for organizing and analyzing complex decisions (not applied in this research)</td>
</tr>
<tr>
<td>WSM</td>
<td>A MCDM method for organizing and analyzing complex decisions (applied in this research)</td>
</tr>
</tbody>
</table>
## Appendix B: List of Definitions of Criteria

<table>
<thead>
<tr>
<th><strong>Project-based</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expected pay-off of method</strong></td>
<td>The benefits gained from applying the improvement methods to the improvement project.</td>
</tr>
<tr>
<td><strong>Budget available for BI method initiative</strong></td>
<td>The maximum amount of money to be spent in the improvement project, which is set in advance of the start of the improvement project.</td>
</tr>
<tr>
<td><strong>Time available before first significant improvement</strong></td>
<td>The maximum amount of time (e.g. months) available before a significant improvement in the business function of business process has to be observed.</td>
</tr>
<tr>
<td><strong>Project goals</strong></td>
<td>The specific goals of the improvement project.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Internal Environment</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organizational structure</strong></td>
<td>It consists of activities which are directed towards the achievement of organizational aims. It provides the foundation on which standard operating procedures and routines rest. It determines which individuals get to participate in which decision-making processes, and thus to what extent their views shape the organization’s actions.</td>
</tr>
<tr>
<td><strong>Size of the company</strong></td>
<td>The size of a company is based upon the total number of employees, the turnover and the balance sheet.</td>
</tr>
<tr>
<td><strong>Past experiences on BI method applications</strong></td>
<td>The extent to whether a company already has business processes or business functions where BI methods were applied in the past.</td>
</tr>
<tr>
<td><strong>Information System architecture</strong></td>
<td>An information system architecture is a formal definition of the business processes and rules, systems structure, technical framework, and product technologies for a business or organizational information system. The architecture of an information system encompasses the hardware and software used to deliver the solution to the final consumer of services.</td>
</tr>
<tr>
<td><strong>Commitment of shareholders, top management and other employees</strong></td>
<td>The commitment of any stakeholder from within the company in the improvement project.</td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td>The industry where the company with the improvement project is operating in.</td>
</tr>
<tr>
<td><strong>Process Maturity Level</strong></td>
<td>The capability of an organization to define, manage, measure and control their processes to use for (constant) process improvement.</td>
</tr>
<tr>
<td><strong>Cultural, Political, Technological and Social</strong></td>
<td>It considers the processes by which structures, including schemas, rules, norms, and routines, become established as authoritative guidelines for behavior.</td>
</tr>
<tr>
<td><strong>Value proposition</strong></td>
<td>The predominant strategic orientation of the improving business unit leading the business improvement project.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>External Environment</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Popularity of BI method</strong></td>
<td>The worldwide popularity of BI methods as fashionable concepts.</td>
</tr>
<tr>
<td><strong>Institutional factors</strong></td>
<td>It comprises all external forces existing in the organizational environment which pressure the adoption of BI methods. The most significant factor among these is the diffusion agents, such as consulting firms, management guru’s and training organizations.</td>
</tr>
<tr>
<td><strong>Political, Economical, Socio-cultural and Technological</strong></td>
<td>Also known as the PEST analysis, this is an analysis of the external macro-environment that affects firms. Such external factors usually are beyond a firm’s control.</td>
</tr>
<tr>
<td><strong>Empirical evidence of BI methods effectiveness</strong></td>
<td>Derived from observations or experiments that the BI method is effective in other settings and/or organizations.</td>
</tr>
<tr>
<td><strong>External customer demand</strong></td>
<td>A company with an improvement project demands the consultants to choose a particular BI method.</td>
</tr>
</tbody>
</table>
**Appendix C: Table of Interviewees and Hierarchical Level**

<table>
<thead>
<tr>
<th>Name of Interviewee</th>
<th>Job Title</th>
<th>Received Criteria Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amer Singh Thakur</td>
<td>Senior Principal</td>
<td>Yes</td>
</tr>
<tr>
<td>Ramesh Paturi</td>
<td>Principal</td>
<td>No</td>
</tr>
<tr>
<td>Tushar Subhra Das</td>
<td>Associate</td>
<td>Yes</td>
</tr>
<tr>
<td>Zubair Ahmed Kaleem</td>
<td>Senior Associate</td>
<td>Yes</td>
</tr>
<tr>
<td>Eswar Ganesan</td>
<td>Senior Associate</td>
<td>Yes</td>
</tr>
<tr>
<td>Neeraj Sulhan</td>
<td>Senior Associate</td>
<td>Yes</td>
</tr>
<tr>
<td>Vivek</td>
<td>Partner</td>
<td>Yes</td>
</tr>
<tr>
<td>Pradeep T.Y.</td>
<td>Senior Principal</td>
<td>No</td>
</tr>
<tr>
<td>Malay Shah</td>
<td>Senior Associate</td>
<td>Yes</td>
</tr>
<tr>
<td>Prakash Jayaram</td>
<td>Senior Principal</td>
<td>No</td>
</tr>
<tr>
<td>Ganesh S</td>
<td>Senior Associate</td>
<td>Yes</td>
</tr>
<tr>
<td>Mitul Thapliyal</td>
<td>Senior Associate</td>
<td>Yes</td>
</tr>
<tr>
<td>Prakash Viswarathan</td>
<td>Senior Principal</td>
<td>Yes</td>
</tr>
<tr>
<td>Jude Fernandez</td>
<td>Senior Associate</td>
<td>Yes</td>
</tr>
<tr>
<td>Subramanyam V.</td>
<td>Senior Associate</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Consultants working in Infosys Bangalore: ± 120 employees
Consultants working in Infosys Worldwide: ± 750 employees
Appendix D: Questionnaire to Consultants

Introduction

For over decades a plethora of Business Improvement methods are used at companies to increase their operational performance and survive in dynamic markets. The field of Business Improvement (BI) methods is rich in the variety in methods. A joint research between Eindhoven University of Technology (The Netherlands) and Infosys Technologies Limited (India) has been set up to investigate the decision-making process and arguments for selecting the application of a method at a specific company. For this research the following methods have been selected to focus on:

- Total Quality Management (TQM)
- Six Sigma
- Business Process Reengineering (BPR)
- Lean
- Business Process Management (BPM)

The interview will focus on your experience concerning the methodologies and techniques used for the selection of these BI methods in a specific application project in which you were significantly involved. Moreover, we are interested in the factors that influenced this selection in this specific application project.

Your input will be a valuable contribution to this research that is aiming to develop a rationalized technique to support practitioners (targeting specifically consultants) in selecting BI methods for a specific application project at a company. Any information that you give in this interview will be treated strictly confidential and anonymous.

Your name: ___________________________
Your job: ___________________________

Responsible researchers:
B.P. Wieleman (University of Technology, Eindhoven)
Dr. ir. Hajo A. Reijers (University of Technology, Eindhoven)
Dr. Manish Kumar (Infosys Technologies Limited, Bangalore)
Dr. P.M.E. van Gorp (University of Technology, Eindhoven)

Software Engineering and Technology Labs
BPM Research Group

Industrial Engineering and Innovation Sciences
Information Systems department
General Questions

1.1 Are you familiar with the principles behind the BI methods of this research? Tick the boxes of the methods from which you know their main principles.

☐ TQM
☐ Lean
☐ Six Sigma
☐ BPR
☐ BPM

1.2 Which of these BI methods have you applied in projects for clients?

☐ TQM
☐ Lean
☐ Six Sigma
☐ BPR
☐ BPM

1.3 Are there other methods which you use for application projects concerning Business Improvement?

_____________________________________________________________________________________

1.4 Can you make an estimation of how many times you have recommended the use of the different BI methods. If you mentioned other methods in Question 1.3, please also provide the amount of recommendations for those methods.

<table>
<thead>
<tr>
<th>BI methods</th>
<th>Number of times recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>TQM</td>
<td></td>
</tr>
<tr>
<td>Lean</td>
<td></td>
</tr>
<tr>
<td>Six Sigma</td>
<td></td>
</tr>
<tr>
<td>BPR</td>
<td></td>
</tr>
<tr>
<td>BPM</td>
<td></td>
</tr>
</tbody>
</table>

Can you recall the last application project of a BI method in which you were significantly involved. Please answer the following question concerning this project.

1.5 Which method did you recommend to apply in this specific project and what were the reasons for selecting this specific project?

_____________________________________________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________
Selection process of BI methods

Do you have a methodology for selecting a suitable BI method for application projects at organizations?

If Yes, then answer question 2.1-2.4. If No, then answer question 2.5-2.6

If Yes,

1.1. What are the steps involved in decision-making?

____________________________________________________________________________
____________________________________________________________________________

1.2. What factors do you take into account when applying your methodology?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

1.3. How long does it approximately take to decide which BI method is most suitable to an organization approximately?

____________________________________________________________________________

1.4. What do you think are current weaknesses of the methodology you use?

____________________________________________________________________________
____________________________________________________________________________

If No,

1.5. How do you choose a BI method? (e.g. recommendations by colleagues/ contacts/ journals/ management books/ management guru’s, to follow competitors)

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

1.6. Would you like to have a structured methodology for the selection of BI methods? Why is this important or not?

____________________________________________________________________________
____________________________________________________________________________

Appendix E: Main Structure of the Interviews

1. Study the questionnaire provided by the interviewee in advance of the interview to ask for more in-depth experiences with selection of BI methods in improvement projects.
2. Welcome the interviewee and introduce myself and the research that I am doing.
3. Ask the person to provide his job experience in the consulting industry and what kind of clients he/she has worked for.
4. Ask about one of the most recent application projects in which he/she was significantly involved.
   a. What steps did he/she follow in the decision making process regarding the BI method selection?
   b. What were influential factors in the decision making process?
   c. To what extent did irrational factors influence the decision making process?
5. What are weaknesses in the decision making process for the selection of BI methods and how do you think they weaknesses can be minimized?
6. Round off with asking the person which opportunities he/she would see in the development of a decision-supporting technique and what this technique should consist off in his/her vision.
7. Follow up: Send the ranking list to the consultants and ask him to provide a ranking of the influential criteria in the decision making process collected from the literature.
Appendix F: Form for Ranking of Influential Criteria

Rank the following criteria on their importance in influencing the selection of BI method application at organizations. They are divided into three separate drivers: Project-based, Internal Environment and External Environment. Project-based is to target the sub-drivers concerning a specific improvement project at a company. Internal environment and External environment are the two other drivers to function as forces from within and outside the organization, respectively.

Rank all criteria on their degree of importance in the selection process of BI methods: 1 (not important), 2 (low importance), 3 (medium importance), 4 (high importance), 5 (very high importance). Leave the field blank if you do not know whether this certain criterion plays a role in the selection process.

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Criteria</th>
<th>Degree of importance (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project-based</strong></td>
<td>Budget available for BI method application</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time available before first significant improvement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project goals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expected pay-off of method</td>
<td></td>
</tr>
<tr>
<td><strong>Internal Environment</strong></td>
<td>Organizational structure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Size of the company</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Past experiences on BI method applications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industry the company is operating in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Process Maturity Level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cultural influences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Political influences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technological influences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social influences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value proposition</td>
<td></td>
</tr>
<tr>
<td><strong>External Environment</strong></td>
<td>Popularity of method</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recommendations by journals/ management books</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recommendations by colleagues/ contacts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recommendations by management guru’s/ training organizations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Political, Economical, Socio-cultural and Technological (PEST) factors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Following competitors’ BI method application</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Empirical evidence of BI method’s effectiveness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>External customer demand</td>
<td></td>
</tr>
</tbody>
</table>

Do you have other criteria that should be considered for the selection of a BI method at a specific application project?

_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
## Appendix G: Criteria Ranking from Consultants

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Criteria</th>
<th>MEAN</th>
<th>MODE</th>
<th>ST DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project-based</strong></td>
<td>Budget available for BI method application</td>
<td>3.363636</td>
<td>3</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>Time available before first significant improvement</td>
<td></td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Project goals</td>
<td>4.166667</td>
<td>4</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Expected pay-off of method</td>
<td>4</td>
<td>4</td>
<td>0.60</td>
</tr>
<tr>
<td><strong>Internal Environment</strong></td>
<td>Organizational structure</td>
<td>2.727273</td>
<td>3</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td>Size of the company</td>
<td>3.272727</td>
<td>3</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td>Past experiences on BI method applications</td>
<td>4.083333</td>
<td>4</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Industry the company is operating in</td>
<td>3.545455</td>
<td>3</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td>Process Maturity Level</td>
<td>3.6</td>
<td>4</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Cultural influences</td>
<td>3.181818</td>
<td>3</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Political influences</td>
<td>2.818182</td>
<td>3</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Technological influences</td>
<td>3.3</td>
<td>4</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>Social influences</td>
<td>2.6</td>
<td>3</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>Value proposition</td>
<td>4.083333</td>
<td>4</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>External Environment</strong></td>
<td>Popularity of method</td>
<td>3.583333</td>
<td>4</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Recommendations by journals/management books</td>
<td>3.090909</td>
<td>3</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>Recommendations by colleagues/contacts</td>
<td>3.363636</td>
<td>3</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Recommendations by management guru’s/ training organizations</td>
<td>3.333333</td>
<td>3</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>Political, Economic, Socio-cultural and Technological (PEST) factors</td>
<td>3.090909</td>
<td>3</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>Following competitors’ BI method application</td>
<td>2.909091</td>
<td>2</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>Empirical evidence of BI method’s effectiveness</td>
<td>3.25</td>
<td>4</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>External customer demand</td>
<td>3.636364</td>
<td>3</td>
<td>1.21</td>
</tr>
</tbody>
</table>
Appendix H: Value Proposition Examples of Companies

This appendix shows examples of companies in each of the values propositions, by Bititci (2001) and a detailed description of each value proposition.

<table>
<thead>
<tr>
<th></th>
<th>Hard Value</th>
<th>Soft Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product Leadership</strong></td>
<td>Technology Leaders</td>
<td>Brand Leaders</td>
</tr>
<tr>
<td></td>
<td>- Intel, Microsoft, Philips, 3M</td>
<td>- Harley Davidson, Nike</td>
</tr>
<tr>
<td><strong>Operational Excellence</strong></td>
<td>Price Minimizers</td>
<td>Process Simplifiers</td>
</tr>
<tr>
<td></td>
<td>- Casio, Honda</td>
<td>- Amazon, Federal Express</td>
</tr>
<tr>
<td><strong>Customer Intimacy</strong></td>
<td>Technological Integrators</td>
<td>Social Integrators</td>
</tr>
<tr>
<td></td>
<td>- IBM</td>
<td>- Home Depot</td>
</tr>
</tbody>
</table>

**Technology Leaders (TL)**

In this case the customers get new products, which they have never seen before, with unique and special characteristics. These type of companies need to focus on building strong design skills, work within short product lifecycles, make obsolete their own products and continuously introduce new products. The strategic objective of Technology Leaders is to provide breakthrough through new designs and product generations within technological basis.

**Brand Leaders (BL)**

Brand Leaders’ customers get status by the product acquisition to feed some feelings, such as superiority, ego and social acceptance among others. Hence, the value that these organizations proposes is a mix of physical attributes of the product, brand, service and even price; because sometimes the price is considered as an attribute to the product especially for brand managers. The strategic objective of ‘Brand Leaders’ is to expand the market reinforcing the solid brand image of the product and/or company.

**Price Minimizers (PM)**

Price Minimizers’ customers get good quality, reliable and conscious price products. In order to sustain this proposition, these organizations need to focus on the development of strong capabilities to reduce lead times, reduce costs and waste and optimize process performance. Their strategic objective is focused on making their production process efficient and driving down operational costs.

**Process Simplifiers (PS)**

Process Simplifiers’ customers get availability and convenience to reach the products. In order to support this proposition, these organizations have to have strong focus and automation on order generation and order fulfillment to take out the hassle from customers. Their strategic objective is focused on building streamlined processes to make life simple and uncomplicated for customers in a creative, novel and profitable way.
**Technological Integrators (TI)**

Technology Integrator’s customers get total solutions, i.e. tailored products and services. In order to support this proposition, these organizations need to support their customers’ processes, helping them to identify and provide new solutions; hence, personalized attention such as product delivery, pre- and post-purchasing service, installation and maintenance, are some of the attributes of their product/service. The strategic objective of Technology Integrators is to customize specific and continuous solutions for carefully selected customers on the basis of long term relationships.

**Social Integrators (SI)**

Social Integrators’ customers get flexible and reliable services. In order to sustain this proposition, these organizations build capabilities of strong service delivery and long relationships with customers. Their strategic objective is focused on building confidence and trust through the service provided. Perhaps their products are not innovative, low price, tailored products, but the type of product and its delivery to their customers build a feeling of confidence of dealing with them. For instance, Social Integrators build confidence by continuous interaction with the customer’s business or supporting anytime their customers require them.
Appendix I: The Instances of Pre-selection criteria

In the table the different instances of the criteria are denoted and the abbreviations used for the criteria Industry, Value Proposition and Process Maturity Level.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Value proposition</th>
<th>Process Maturity level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture (AC)</td>
<td>Brand Leaders (BL)</td>
<td>1</td>
</tr>
<tr>
<td>Chemicals (CH)</td>
<td>Price Minimizers (PM)</td>
<td>2</td>
</tr>
<tr>
<td>Commercial (CO)</td>
<td>Process Simplifiers (PS)</td>
<td>3</td>
</tr>
<tr>
<td>Financial (FI)</td>
<td>Social Integrators (SI)</td>
<td>4</td>
</tr>
<tr>
<td>Government (GO)</td>
<td>Technological Integrators (TI)</td>
<td>5</td>
</tr>
<tr>
<td>Healthcare (HC)</td>
<td>Technology Leaders (TL)</td>
<td></td>
</tr>
<tr>
<td>IT (IT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing (MA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-profit (NP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation (TR)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix J: Number of publications per year from 1991 to 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>TQM</th>
<th>Six Sigma</th>
<th>Lean</th>
<th>BPR</th>
<th>BPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>444</td>
<td>38</td>
<td>29</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1992</td>
<td>1404</td>
<td>77</td>
<td>148</td>
<td>29</td>
<td>10</td>
</tr>
<tr>
<td>1993</td>
<td>2395</td>
<td>75</td>
<td>235</td>
<td>508</td>
<td>12</td>
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<tr>
<td>1994</td>
<td>2282</td>
<td>102</td>
<td>270</td>
<td>1063</td>
<td>30</td>
</tr>
<tr>
<td>1995</td>
<td>1979</td>
<td>98</td>
<td>255</td>
<td>1312</td>
<td>22</td>
</tr>
<tr>
<td>1996</td>
<td>1723</td>
<td>112</td>
<td>328</td>
<td>1120</td>
<td>47</td>
</tr>
<tr>
<td>1997</td>
<td>1664</td>
<td>136</td>
<td>383</td>
<td>827</td>
<td>76</td>
</tr>
<tr>
<td>1998</td>
<td>1744</td>
<td>316</td>
<td>664</td>
<td>861</td>
<td>159</td>
</tr>
<tr>
<td>1999</td>
<td>1557</td>
<td>473</td>
<td>750</td>
<td>666</td>
<td>340</td>
</tr>
<tr>
<td>2000</td>
<td>1351</td>
<td>908</td>
<td>923</td>
<td>510</td>
<td>529</td>
</tr>
<tr>
<td>2001</td>
<td>1230</td>
<td>1328</td>
<td>1180</td>
<td>481</td>
<td>722</td>
</tr>
<tr>
<td>2002</td>
<td>1261</td>
<td>1514</td>
<td>1460</td>
<td>590</td>
<td>998</td>
</tr>
<tr>
<td>2003</td>
<td>1206</td>
<td>1887</td>
<td>1534</td>
<td>606</td>
<td>1268</td>
</tr>
<tr>
<td>2004</td>
<td>1208</td>
<td>2503</td>
<td>2221</td>
<td>562</td>
<td>1898</td>
</tr>
<tr>
<td>2005</td>
<td>1217</td>
<td>3274</td>
<td>2859</td>
<td>726</td>
<td>2181</td>
</tr>
<tr>
<td>2006</td>
<td>1271</td>
<td>3341</td>
<td>2798</td>
<td>750</td>
<td>2178</td>
</tr>
<tr>
<td>2007</td>
<td>1104</td>
<td>3208</td>
<td>2657</td>
<td>613</td>
<td>2052</td>
</tr>
<tr>
<td>2008</td>
<td>1056</td>
<td>2779</td>
<td>2556</td>
<td>533</td>
<td>1681</td>
</tr>
<tr>
<td>2009</td>
<td>864</td>
<td>2398</td>
<td>2009</td>
<td>388</td>
<td>1708</td>
</tr>
<tr>
<td>2010</td>
<td>1046</td>
<td>2219</td>
<td>1673</td>
<td>374</td>
<td>1655</td>
</tr>
</tbody>
</table>
Appendix K: Hypothetical Decision Making: Buying a Car

Selecting the best car among three candidate cars, say car A, car B and car C can be seen as a hypothetical MCDM problem. The decision criteria may refer to price, mileage per gallon and the physical attractiveness of a car (Triantaphyllou, 2000). That is, we have three criteria influencing the decision making process. Of these three criteria, the first two are easy to quantify as one may have the exact price value of each car and also the exact fuel consumptions (Triantaphyllou, 2000). On the other hand, expressing the alternatives in terms of the last criterion might be trickier as that criterion is a qualitative one. In such examples one may use relative values to express how much a given car is more desirable than another car. Moreover, the relative importance of the three criteria (weights) can be very subjective and different decision makers may assign totally different values to the criteria weights. The data for the car selection problem has been provided in the table on this page. The first two decision criteria columns are fixed and the third column is subjective based on the relative physical attractiveness of the car (10 points to be dedicated to this criterion). From this decision matrix there is not one specific car that scores best on all the criteria if the goal of the buyer is to minimize the price, minimize the mileage and maximize the physical attractiveness of the car.

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>Price (€)</th>
<th>Mileage (km/liter)</th>
<th>Physical Attractiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weights</td>
<td>W₁</td>
<td>W₂</td>
<td>W₃</td>
</tr>
<tr>
<td>Car A</td>
<td>20.000</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>Car B</td>
<td>27.500</td>
<td>28</td>
<td>5</td>
</tr>
<tr>
<td>Car C</td>
<td>22.500</td>
<td>36</td>
<td>3</td>
</tr>
</tbody>
</table>

Since there are three decision criteria of heterogeneous units in this problem, we speak of a multi-dimensional decision problem. The relative weights (W₁, W₂, W₃) can be for instance as follows: W₁ = 0.50, W₂ = 0.20, W₃ = 0.30. One can see that there is a high influence of subjectivity (in both the values of the physical attractiveness of the cars and the weights of the influential criteria) in the decision supporting techniques.
Appendix L: Definitions of MADM Models

The Weighted Sum Model

The WSM is the earliest and probably the most widely used method (Fishburn, 1967), especially in single dimensional problems. If we use the notation of Definition 1, the best alternative (denoted as $A_{WSM}^i$) is the one that satisfies the following expression:

\[(1.1)\]

$$A_{WSM}^i = \max_j \sum_{j=1}^{N} a_{ij} w_j$$

The assumption that governs this model is the additive utility assumption, which is the total value of each alternative is equal to the sum of products given as (1.1). In single-dimensional cases, in which all the units are the same (e.g. euros, km’s, seconds), the WSM can be used without difficulty. However, difficulty with this method emerges when it is applied to multi-dimensional decision-making problems. Then, in combining different dimensions, and consequently different units, the additive utility assumption is violated and the result is equivalent to “adding apples to oranges” (Triantaphyllou et al., 1998).

The Weighted Product Model

The WPM is very similar to the WSM. The main difference is that instead of addition in the model, there is a multiplication. Each alternative is compared with the others by multiplying a number of rations, one for each criterion. Each ration is raised to the power equivalent to the relative weight of the corresponding criterion. In general in order to compare the alternatives $A_K$ and $A_L$ (denoted as $(A_K/A_L)$ ) the following product (Miller and Starr, 1969) has to be calculated:

\[(1.2.1)\]

$$R (A_K/A_L) = \prod_{j=1}^{N} (a_{kj}/a_{lj})^{w_j}$$

If the term $R (A_K/A_L)$ is greater than one, then the alternative $A_K$ is more desirable than alternative $A_L$. The best alternative is the one that is better than or at least equal to all the other alternatives. The WPM is sometimes called the dimensionless analysis because its structure eliminates any units of measure. Thus, the WPM can be used in single- and multi-dimensional decision-making problems. An alternative approach is one to use only products without ratios. Then (1.2.1) becomes the following:
(1.2.2)  

\[ P(A_K) = \prod_{j=1}^{N} (a_{Kj})^{w_j} \]

The Analytical Hierarchy Process

Saaty (1980) developed the Analytical Hierarchy Process, which is based on decomposing a complex MCDM problem into a system of hierarchies. The final step in the AHP deals with the structure of the \( MxN \) matrix, which is constructed by using the relative importance of the alternatives in terms of each criterion. The vector \( (a_{i1}, a_{i2}, a_{i3},...,a_{iN}) \) for each \( i \) is the principal eigenvector of an \( N \times N \) reciprocal matrix which is determined by pairwise comparisons of the impact of the \( M \) alternatives on the \( i \)-th criterion (Triantaphyllou et al., 1998). According to AHP the best alternative is indicated by the following relationship:

(1.3)

\[ A_{\text{AHP}}^* = \max_i \sum_{j=1}^{N} a_{ij}w_j \]

Subject to (1.3.1)

\[ \sum_{i=1}^{N} a_{ij} = 1 \]

Expression (1.3.1) makes sure that the columns in the decision matrix have been normalized to add up to 1. The similarity between the WSM and the AHP is evident. The AHP uses relative values instead of actual ones. Thus it can be used in single- or multi-dimensional decision making problems.

The Revised Analytical Hierarchy Process

Belton and Gear (1983) proposed a revised version of the AHP model. They demonstrated that an inconsistency can occur when the AHP is used. They showed that the indication of the best alternative changes when an identical alternative to one of the nonoptimal alternatives is introduced as a new variable. According to Belton and Gear (1983), this inconsistency is the fact that the relative values for each criterion sum up to one. Instead of having the relative values of the alternatives \( A_1, A_2, A_3, ..., A_M \) sum up to one, they propose to divide each relative value by the maximum value of the relative values. The revised AHP was sharply criticized by Saaty (1990). He claimed that identical alternatives should not be considered in the decision process. However Triantaphyllou and Mann (1989) have demonstrated that logical contradictions are possible with the original AHP, as well as with the revised AHP, when non-identical alternatives are introduced.
Appendix M: Hypothetical Use of MADM Methods

The following example is based on Triantaphyllou et al. (1998), but has been edited to improve clarity and readability.

Suppose that an MADM problem involves four criteria, which are expressed in exactly the same unit, and three alternatives. The relative weights of the four criteria were determined to be: \( W_1 = 0.20 \), \( W_2 = 0.15 \), \( W_3 = 0.40 \) and \( W_4 = 0.25 \). The corresponding \( a_{ij} \) values are assumed to be as follows:

\[
A = \begin{bmatrix}
25 & 20 & 15 & 30 \\
10 & 30 & 20 & 30 \\
30 & 10 & 30 & 10
\end{bmatrix}
\]

Therefore, the decision matrix for this MADM problem is as follows:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>( C_1 )</th>
<th>( C_2 )</th>
<th>( C_3 )</th>
<th>( C_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weights</td>
<td>0.20</td>
<td>0.15</td>
<td>0.40</td>
<td>0.25</td>
</tr>
<tr>
<td>( A_1 )</td>
<td>25</td>
<td>20</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>( A_2 )</td>
<td>10</td>
<td>30</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>( A_3 )</td>
<td>30</td>
<td>10</td>
<td>30</td>
<td>10</td>
</tr>
</tbody>
</table>

When the formula (1.1) for \( WSM \) is applied on the previous data, the scores of the three alternatives are:

\[
A_1(WSM) = 25 \times 0.20 + 20 \times 0.15 + 15 \times 0.40 + 30 \times 0.25 = 21.50
\]

Similarly, \( A_2(WSM) = 22.00 \),

And \( A_3(WSM) = 20.00 \).

Therefore, the best alternative (in the maximization case) is alternative \( A_2 \) (because it has the highest WSM score; 22.00). Moreover, the following ranking is derived: \( A_2 > A_1 > A_3 \) (where "\( > \)" stands for "better than").

When the formula (1.2.1) for \( WPM \) is applied on the previous data (note that now the restriction to express all criteria in terms of the same unit is not needed), the scores of the three alternatives are:

\[
R(A_1/A_2) = (25/10)^{0.20} \times (20/30)^{0.15} \times (15/20)^{0.40} \times (30/30)^{0.25} = 1.007 > 1.
\]

Similarly, \( R(A_1/A_3) = 1.067 > 1 \),

And \( R(A_2/A_3) = 1.059 > 1 \).

Therefore, the best alternative is \( A_1 \), as the ranking comparisons with \( A_2 \) and \( A_3 \) are greater than 1. Moreover, the following ranking is derived: \( A_1 > A_2 > A_3 \).
When the formula (1.3) for AHP is applied on the previous data a new decision matrix has to be made where the columns in the decision matrix have been normalized to add up to 1. This is because AHP uses a series of pairwise comparisons to determine the relative performance of each alternative in terms of each one of the decision criteria. The decision matrix now looks as follows:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>$C_1$</th>
<th>$C_2$</th>
<th>$C_3$</th>
<th>$C_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weights</td>
<td>0.20</td>
<td>0.15</td>
<td>0.40</td>
<td>0.25</td>
</tr>
<tr>
<td>$A_1$</td>
<td>25/65</td>
<td>20/55</td>
<td>15/65</td>
<td>30/65</td>
</tr>
<tr>
<td>$A_2$</td>
<td>10/65</td>
<td>30/55</td>
<td>20/65</td>
<td>30/65</td>
</tr>
<tr>
<td>$A_3$</td>
<td>30/65</td>
<td>10/55</td>
<td>30/65</td>
<td>10/65</td>
</tr>
</tbody>
</table>

The scores for the three alternatives with regard to AHP now become as follows:

$$A_1(AHP) = \left( \frac{25}{65} \right) \times 0.20 + \left( \frac{20}{55} \right) \times 0.15 + \left( \frac{15}{65} \right) \times 0.40 + \left( \frac{30}{65} \right) \times 0.25 = 0.34$$

Similarly, $A_2(AHP) = 0.35$,
And $A_3(AHP) = 0.31$.

Therefore, the best alternative (in the maximization case) is the alternative $A_2$ (because it has the highest AHP score; 0.35). Moreover, the following ranking is derived: $A_2 > A_1 > A_3$. □
Appendix N: The Decision Support Technique

N1. Phase 1: Elimination-based

Phase 1 is showed in Figure 8. The yellow cells need to be filled in by the user. When a cell is selected an input message (e.g. “Type the name of the Company”) shows which helps the user what is required to fill in. When the cells of the organizational characteristics are selected (“Industry”, “Value proposition” and “Process Maturity Level”) a short definition of the concepts are given. An orange help box is showed at the bottom of Figure 8 in order to provide extra guidance to the user.
Figure 9. Decision Support Technique (2)

In Figure 9 you see that the information filled in leads to the de-selection of BI methods Lean and BPR, because Process Maturity Level 4 was selected. When the cell is selected, a drop-down list appears with a blank line and 1 to 5. The grey cells give the acronym of the industry and the explanation of level 4, when the cell input is given. This is caused by a “IF-THEN-ELSE”-formula.

=IF(B12=1; "Initial Level"; IF(B12=2; "Managed Level"; IF(B12=3; "Defined Level"; IF(B12=4; "Quantitatively Managed Level"; IF(B12=5; "Optimizing Level"; "")))))

Filling in one of the organizational constraints for a BI method will cause the name to switch the green cell to the red cell. E.g. the formula of the green cell for Lean is as following:

=IF(B12=4;"";IF(B12=5;"";"Lean"))

If the Process maturity level is 4 or 5, the green cell of Lean will remain empty ("""). The formula of the red cell for Lean is as following:

=IF(C17=""; "Lean"; "")

If the green cell is empty, the red cell gets the name “Lean” as it should be de-selected.
## 2. Phase 2: Scoring Model

### Figure 10. Decision Support Technique (3)

Figure 10 shows the score input that needs to be provided for the second phase of the DST. Based on the weights of the criteria and the company’s aim scores, a score for each pre-selected method will be calculated. Like in the other phase, orange help boxes are provided and selecting the cell of the criteria will provide a brief definition of the concept. If the weight cells are selected, a drop-down list will occur where a weight between 10% and 100% can be selected. The weights should sum to 100% and that is when the cell of “Summation of Weights” will get a black color. This has been done through the function Conditional Formatting in Excel. The same counts for the aim score cells. If the summation for the criteria Project Goals and Expected Pay-off are 20 and 10 respectively, the font will also get a black color.
In Figure 11 an example has been provided with input data for the scoring model. Scores are given only for the methods that have been pre-selected (TQM, Six Sigma and BPM). A decision maker could use the ranking for supporting its decision. Although, when the decision maker wants more insights on where the score is based upon and which BI methods get a good score per criterion.

![Figure 11. Decision Support Technique (4)](image)

<table>
<thead>
<tr>
<th>Criterion Name</th>
<th>Weight of Criteria (10 - 100)</th>
<th>Sub-criteria</th>
<th>Company's Aim Score (1-10)</th>
<th>Summation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Goals</td>
<td>30</td>
<td>Time (Speed)</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flexibility</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quality</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Expected Payoff</td>
<td>60</td>
<td>Operational Effectiveness</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strategic Positioning</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Popularity of Method</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The worldwide popularity of BI methods as fashionable concepts

<table>
<thead>
<tr>
<th>Ratio</th>
<th>TQM</th>
<th>Six Sigma</th>
<th>Lean</th>
<th>BPR</th>
<th>BPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scores</td>
<td>1,01</td>
<td>0,91</td>
<td>NOT SELECTED</td>
<td>NOT SELECTED</td>
<td>0,86</td>
</tr>
<tr>
<td>Rank</td>
<td>3</td>
<td>2</td>
<td>NOT SELECTED</td>
<td>NOT SELECTED</td>
<td>1</td>
</tr>
<tr>
<td>Criterion Name</td>
<td>Weight per Criterion</td>
<td>Sub-criteria</td>
<td>Relative Weight</td>
<td>Company’s Aim Score</td>
<td>Method’s Score</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------</td>
<td>--------------</td>
<td>----------------</td>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Time (Speed)</td>
<td>7.5</td>
<td>3</td>
<td>0.0</td>
<td>1.086</td>
<td>2</td>
</tr>
<tr>
<td>Cost</td>
<td>7.5</td>
<td>4</td>
<td>0.5</td>
<td>0.950</td>
<td>9</td>
</tr>
<tr>
<td>Flexibility</td>
<td>7.5</td>
<td>3</td>
<td>0.3</td>
<td>1.031</td>
<td>2</td>
</tr>
<tr>
<td>Quality</td>
<td>7.5</td>
<td>7</td>
<td>0.2</td>
<td>0.981</td>
<td>7</td>
</tr>
<tr>
<td>Total Project Goals</td>
<td>30</td>
<td>20</td>
<td>1.0</td>
<td>20.105</td>
<td>20</td>
</tr>
<tr>
<td>Expected Payoff</td>
<td>60</td>
<td>9</td>
<td>0.8</td>
<td>0.93</td>
<td>10</td>
</tr>
</tbody>
</table>

**Figure 12. Decision Support Technique (S)**

Figure 12 has copied the weights and aim scores of the criteria given by the decision maker. The scores of each method are fixed and based upon the WPM a score is calculated for each sub-criterion. The Relative score for sub-criterion Time(Speed) for TQM is calculated as follows:

\[=IF($F$2="SELECTED"; (($E5/$F5)^($D5/100)); "N/A")\]

If the method is selected from phase 1, the method will get a score otherwise it will get the string “N/A” (not applicable). If it is selected, the company aim score is divided by the method’s score and compensated for the relative weight of the sub-criterion.

Figure 13. Decision Support Technique (6)

Figure 13 shows the calculation of the score robustness for each criterion. If the cell is green, the value resembles the percentage required to increase/decrease the weight of the criterion which will cause the break-even point to be reached. If the cell is red it is mathematically impossible to reach the break-even point by changing the weights of a criterion.
Figure 14. Decision Support Technique (7)

Figure 14 shows the graphical display of the total scores and the score for each sub-criterion. A line is drawn at the score 1.00 where the break-even point is.
Figure 15. Decision Support Technique (8)

This is the last figure (Figure 15) of the Sensitivity Analysis, where graphical displays are given in radar charts per sub-criterion for each of the selected methods. This gives the decision maker the ability to see which aim scores are not in accordance with the method scores.
## Appendix O: Participants in the Evaluation

### Infosys

<table>
<thead>
<tr>
<th>Name of Interviewee</th>
<th>Job Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eswar Ganesan</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Vivek</td>
<td>Partner</td>
</tr>
<tr>
<td>Pradeep T.Y.</td>
<td>Senior Principal</td>
</tr>
<tr>
<td>Malay Shah</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Prakash Jayaram</td>
<td>Senior Principal</td>
</tr>
<tr>
<td>Ganesh S</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Mitul Thapliyal</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Prakash Viswarathan</td>
<td>Senior Principal</td>
</tr>
<tr>
<td>Jude Fernandez</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Subramanyam V.</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Mayank Gupta</td>
<td>Senior Principal</td>
</tr>
<tr>
<td>Shivi Mithal</td>
<td>Principal</td>
</tr>
</tbody>
</table>

### IBM

<table>
<thead>
<tr>
<th>Name of Interviewee</th>
<th>Job Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vincent le Noble</td>
<td>Senior Principal</td>
</tr>
<tr>
<td>Jasper Visscher</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Erick Haag</td>
<td>Principal</td>
</tr>
<tr>
<td>Joris van Hijfte</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Roald Droog</td>
<td>Principal</td>
</tr>
</tbody>
</table>

### Deloitte

<table>
<thead>
<tr>
<th>Name of Interviewee</th>
<th>Job Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reynout Vos</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Günther Drabbels</td>
<td>Senior Associate</td>
</tr>
<tr>
<td>Maarten Leurs</td>
<td>Senior Associate</td>
</tr>
</tbody>
</table>
Appendix P: Case Study for Evaluation

Case Study 1: ‘Construct Limited’

Background

Construct Limited is an infrastructure construction company. Today, it is acknowledged as a company that continues to enable the nation to surge ahead in different core sectors. Construct Limited is an industry leader in engineering construction, currently nurtures projects that span across such diverse segments as transportation, power, marine projects, oil and gas pipeline constructions, irrigation and water supply, utilities and urban infrastructure.

Mission

- To be a leading construction company in the global market.
- To become the customers’ most preferred choice by attaining excellence in quality and timely completed value added projects.
- To continually innovate, develop and adopt state-of-the-art technology in methods and materials to enhance productivity and cost effectiveness.

Problem Statement

Construct Limited specializes in large-scale civil constructions by leveraging new age construction technologies. They have taken part in some prestigious projects, creating everything from roads and bridges to dams and barrages, nuclear power generators and tunnels and metros. Construct Limited is a large consumer of the earth’s resources in terms of raw materials and energy. The department ‘Operations Management’ wants to increase the efficiency of the use of the earth’s resources and make Construct Limited a more sustainable company. At the moment, standard processes for materials re-use and separation has been developed and has been documented. They have characterized standards and procedures to enable materials re-use, but the process is not measured and it is unclear whether it operates within measurable limits.

Desired State

Construct Limited would like to imply serious design efforts to facilitate the separation and reuse of materials when a construction project takes place. Materials should not end up in an incinerator or landfill, but need to be recycled ‘cradle to cradle’. Moreover, Construct Limited would like to have selected metrics through which they can measure the improvement of re-use and separation of their materials. This quantitative measuring system is not in place at the moment and it should enable them to see whether they operate within measurable limits. These limits will also need to be defined.

Time

The duration of the project is 3 months.
Appendix Q: Evaluation Guide

In this evaluation you can always ask for extra information about the case study or the decision support technique if you need this. Your input will be a valuable contribution to this research. Any information that you give in this interview will be treated strictly confidential and anonymous.

**Background**

Your name: ______________________

Your job: ______________________

Which of the following methods have you applied in projects for clients?

- [ ] Impact Framework (Infosys)
- [ ] Lean
- [ ] Six Sigma
- [ ] BPR
- [ ] BPM
- [ ] TQM

**Part I**

Read through the case study provided. If you needed to select one or more methods to use in this improvement project, which would it be and why? You can choose from the defined business improvement methods (Six Sigma, Lean, TQM, BPR, BPM) or tools from the Impact Framework.

I would choose for __________________________________________________________

because ______________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

**Part II**

Try to fill in Step 1 and Step 2 of the decision support technique. You only need to fill in the yellow-colored cells of the two worksheets.

**Step 1:**

The first step to take is the **constraint-based approach**. We start off with collection $A$ of BI method alternatives as:

$$ A = \{TQM, \text{Six Sigma}, \text{Lean}, \text{BPR}, \text{BPM}\} $$

In Step 1, there will be a pre-selection determined based on the values of the criteria you provided. The following criteria are selected for this step:

- Industry
- Value proposition
- Process Maturity Level

If you have any questions about the categorical values of the criteria, please ask them to the facilitator.

**Step 2:**

The second step is filling in the weights to the criteria from the ‘Project-based’ and ‘External Environment’ dimensions:

- Project goals (Project based)
- Expected pay-off (Project-based)
- Popularity of the method (External Environment)

The criteria for Project-based are variables based on the choice of a company.

There are weights to be assigned to the importance of each criterion to the company which is a value between 0 and 100 where the sum of the weights should add up to 100.

The criteria should be rated to measure how well each BI method achieved each of the defined criteria. You should provide a score for the company where they would like to aim their improvement project on. For instance, if a company wants to focus on Quality in their Project goals-criterion then a higher score can be dedicated to that sub-criterion. The score range is [1-10] per sub-criterion and the maximum amount of point to be dedicated to each criterion is 20 points and 10 points that can be dedicated to Project Goals and Expected Pay-off respectively. No scores are required for the Popularity.

**Part III**

You will now be provided with an example of how the scoring could be filled in and an explanation will be provided by the facilitator on how the scoring method works in more detail.

**Part IV**

You are now asked to fill in the evaluation form which will provide input for the researchers to redesign the decision supporting technique. The three main criteria where the evaluation form is based upon are:

1. The decision supporting model should be easy to understand and use for managers and other decision makers. (**Understandability and Usability**)
2. The decision supporting model should be easy to control and adapt for managers and other decision makers. (**Adaptability**)
3. The decision support model should support traceability of the outcome for managers and other decision makers. (**Traceability**)

You are asked to provide a score on a rating scale from [1-5]. There will be some statements for each evaluation criterion. For every statement you are asked to what degree you agree or disagree with the statement. The scores mean the following: 1 = strongly disagreed, 2 = disagreed, 3 = neither agreed nor disagreed, 4 = agreed, 5 = strongly agreed.
Appendix R: Evaluation Form

Please select the score to which you agree with the statement and if possible, could you suggest any areas of improvement for the Decision Support Technique.

<table>
<thead>
<tr>
<th>Assessment criteria</th>
<th>1 strongly disagreed</th>
<th>2 disagreed</th>
<th>3 neither agreed nor disagreed</th>
<th>4 agreed</th>
<th>5 strongly agreed</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Understandability and Usability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The objectives of the decision support technique were clear</td>
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<tr>
<td>The steps in the decision support technique were easy to follow</td>
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<tr>
<td>The decision support technique was easy to use</td>
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<tr>
<td>I did not have to ask the facilitator a lot for help</td>
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<tr>
<td>If I would use the technique again for a new case, it would be easy to fill in.</td>
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<tr>
<td>• Adaptability</td>
<td></td>
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<tr>
<td>I could easily adapt the weights of the criteria</td>
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<tr>
<td>I could easily adapt the company’s aim score</td>
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<tr>
<td>I could see how in Step 3, I can adapt the method’s scores for each criterion</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>• Traceability</td>
<td></td>
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<tr>
<td>After the example, it was easy to derive how the decision support technique came to its ranking.</td>
<td></td>
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</tr>
<tr>
<td>• Suggestions</td>
<td></td>
<td></td>
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<tr>
<td>Strengths of the Decision Support Technique</td>
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<tr>
<td>Weaknesses of the Decision Support Technique</td>
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<tr>
<td>Suggestions for Improvement</td>
<td></td>
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</tr>
</tbody>
</table>
# Appendix S: Suggested benefits of Expected Pay-off categories

<table>
<thead>
<tr>
<th>Pay-off Categories</th>
<th>Suggested benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shareholder benefits</strong></td>
<td>Increase in stock market price.</td>
</tr>
<tr>
<td><strong>Company performance</strong></td>
<td>Increase in financial performance (profitability, cost reduction), Quality performance (reduce nonconformity, shorter lead time), Operating performance (increase productivity, improve cycle time).</td>
</tr>
<tr>
<td><strong>Market performance</strong></td>
<td>Increase marketing effectiveness.</td>
</tr>
<tr>
<td><strong>Customer Satisfaction</strong></td>
<td>Increase customer satisfaction.</td>
</tr>
<tr>
<td><strong>Human Resources</strong></td>
<td>Reduce the number of resources used, increase employees’ skills and provide rewards and recognition.</td>
</tr>
<tr>
<td><strong>Process Improvement</strong></td>
<td>Process innovation breakthrough, reduce process variation and create stability, promote procedural and standardization of work, improve workflow, reduce the number of non-value adding activities and waste.</td>
</tr>
<tr>
<td><strong>Organizational benefits</strong></td>
<td>Improve competitiveness, effectiveness and flexibility of a whole organization. Create an agile and learning organization, improve organizational culture, motivate quality awareness.</td>
</tr>
</tbody>
</table>