Extending the Role of Business Intelligence Information Systems for Closed-loop Management Control

A Master's Thesis submitted for the degree of "Master of Science"

supervised by
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Affidavit

I, **Robert Fidler**, hereby declare

1. that I am the sole author of the present Master Thesis, 'Extending the Role of Business Intelligence Information Systems for Closed-loop Management Control', 92 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master Thesis as an examination paper in any form in Austria or abroad.

Vienna, _____ _____

Date Signature

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ABSTRACT

Corporate investments in information technology continue to increase all over the world, and scientific and industry research demonstrate that utilizing this spending by providing an efficiency-increasing control system to non-manufacturing processes as well could substantially enhance the quality of organizational management.

A feasible solution for this challenge is the application of closed-loop system control principles to organizational management. Such a system can be realized by using available software technology such as business intelligence systems.

After reviewing possible expectations that vendors create through communicating BI vision and product capabilities, it has been revealed and that contemporary BI implementations are not capable to deliver a comprehensive system for supporting management control on their own. There is also only limited evidence of such control systems being successfully created by integrating BI systems into larger hierarchical systems that would achieve this objective.

From the survey results it was evident that extended capabilities of comprehensive management control systems were indeed attractive for users and designers of BI information systems. Yet there is an obvious deficit of sufficient information about system control principles among professionals in business intelligence. Product vendors and industry analysts need to find improved ways of communicating the benefits and capabilities of closed-loop management control in order to propagate this reasonable concept in the market. Lack of process-orientation, and neglecting a top-down systems approach when implementing BI information systems in organizations, could not have been clearly correlated as a cause for the limited adoption of closed-loop management control systems.

Further research is necessary to improve the relevance of the results by increasing the sample size and include respondents from multiple geographic areas and market segments.

1 INTRODUCTION

The purpose of the introductory chapter is to provide some background information to the field of interest for this study, analyze the research problem and define the research objective, from where actual research questions are induced. Furthermore, an overview of the thesis structure is also given.

1.1 Background and Context of Thesis

Along the digital revolution in technology and society came an increasing importance of information systems (IS) in business organizations. Corporations use information systems for supportive functions such as finance and human resources as well as for operational purposes such as production. Information systems increase efficiency, provide a competitive advantage, and even allow the development of new business that would otherwise not have been possible. Their general objective within a business organization is the same as for any other activity or technology that has been introduced in the past: to decrease cost, increase revenue, and add economic value (Laudon & Laudon, 2010). To illustrate the increasing relevance of information systems for corporations, Laudon and Laudon (2010) discussed U.S. Department of Commerce data that shows U.S. corporate capital investments on information systems have raised from 32% of total capital investments in 1980 to 51% in 2008, which is an increase of almost sixty percent. There is no sign of reversal, concepts such as ‘world flattening’ as described by Friedman (2006) or the emergence of ‘digital firms’ continue to add to this trend.

The application of information systems in business organizations has started on a basic level by providing support functions and has grown into more complex roles such as managing supply chain systems. In the contemporary organizational environment, information systems are utilized either for operational tasks or management support. In operations, information systems started with transaction processing for accounting or enterprise resource planning (ERP) systems, are being applied to control production lines in manufacturing, and are now offering capabilities to model and execute any business process, covering also service businesses. In management support, information systems are delivering knowledge

about the state of operations and the business environment to decision makers. While initially these business intelligence (BI) systems provided only bare data for managers to make fact-based decisions, current systems supply statistical trend analysis, forecasting capabilities, and calculation of an optimized course of action.

What is a possible future development of information systems in business from this position, given the mature technical capabilities and increased investments of organizations in information systems? Businesses in the manufacturing domain have long-time experience in applying information systems to control production lines. These systems are based on principles of electronic and mechanical engineering for systems control and were introduced to achieve higher levels of efficiency by reducing variance and waste in the production process. Their basic mode of operation is a continuous cycle of measuring the current state of production, compute control actions, and effect the required changes in the production system. Given the increasing number of service organizations among businesses, it would be desirable to provide an efficiency-increasing control system to non-manufacturing processes as well. Furthermore, the elevation of this control concept to the generic task of organizational management would create an information systems category that could support any manager in efficiently steering the enterprise, regardless of business domain.

How could such a system be implemented? Its objective is to support management through a comprehensive closed-loop control system of business procedures, building on the principles of a continuous cycle of measuring feedback, making decisions, and effecting actions as applied by other control systems. A promising approach to solving this challenge is the convergence of capabilities of business intelligence systems and operational business process management systems to achieve this closed-loop cycle.

While this notion of a management control information system is originating from a business context, such a system would undoubtedly not only be attractive for commercial enterprises. It would prove to be valuable for any type of organization, be it governmental, defense, or non-profit.

Finally, what would be the actual value of a management control information system? It would significantly add value to the organization by increasing efficiency in the management of organizations through advanced methods in decision-making, based on factual feedback, and minimizing ambiguity and waste in the translation of management decisions through defined and traceable processes.

1.2 Research Problem

Generally, the structured approach to managing organizations can be traced back to the principles of 'Scientific Management' as postulated by Taylor (2003). Managing business processes and organizations should no longer be based on 'gut-level feeling' and rules-of-thumb, but rather on factual data and scientific methods in order to reduce variance and waste in (production) processes. This initial works and further research that built on these principles were also employing the concepts of process-orientation and systems as a grouping of interrelated processes with a common purpose. The same principles can be found in contemporary quality management methodologies, e.g. EN/ISO 9001:1994 (1994), which assist organizations with guidelines on improving and managing the quality of conducting business, also encompassing the quality of managing the organization itself.

Coming from this systems approach background, the field of control engineering provides scientific methods on how to approach the control of systems. The basic principle of (closed-loop) system control is a continuous closed cycle of receiving feedback, making a control decision, and carrying out the resulting action. While control engineering is deeply rooted in electrical and mechanical engineering and is often perceived to be concerned only with researching means of control for technical systems, Wiener (1948) has shown in his theory of Cybernetics that control principles are valid for non-technical systems, such as natural or social systems.

Business intelligence information systems were introduced in organizations in order to support management in exercising control of the business from a strategic and tactical perspective. Enabled by advances in research and technology, and partially driven by industry analysts, BI software vendors have recently intensified their market communication regarding closed-loop support systems for managing organizations in their marketing material and product documentations. This trend has

produced catch phrases such as ‘actionable intelligence’ (Oracle Corporation, 2010a) or ‘end-to-end business intelligence’ (SAP AG, 2009b) and is accompanied by an extension of BI into supporting operational management. Naturally, customers of BI software systems are adopting this expectation on the system’s capabilities set by vendors and consultants.

However, cases of practical application of business intelligence products for tasks in the area of organizational management, especially within the services domain, appear to cover only a limited portion of the closed-loop control cycle, as opposed to information systems used for production line control in manufacturing. In the majority of cases, implementations of BI systems are utilized for receiving feedback from the operational system and providing basic information processing for decision support, lacking capabilities for advanced formalized decision-making and structured and traceable processes for disseminating management decision outcomes into business operations.

As management processes can have a large degree of randomness, through factors such as human behavior, significant variance in ‘gut-level’ decisions, lack of process definition, and lack of traceability, it is at best challenging for many organizations to achieve the process control objectives set by quality management methodologies such as ISO 9001, TQM, or Six Sigma, without proper information system support.

Contemporary BI products are not capable to fully support such a closed-loop management control system as advertised by the product vendors. There is a functional gap between expectations set through vendor communication and actual product capabilities. Assuming that information systems that support closed-loop management control systems are attractive for organizations, this gap must be closed, either through extended capabilities built into BI products, or through integrating BI systems into larger hierarchical systems that provide the closed-loop control.

1.3 Research Objective

While advancements in the area of business intelligence information systems are reliably being given attention by scientific and industry research initiatives, and particularly the convergence of business intelligence and business process

management information systems, less effort is being made investigating the problems of applying systems control principles through information systems to solve challenges in organizational management. Although this topic is being addressed by industry analysts and information system vendors, there is little engagement to question issues such as the true capabilities of available BI products regarding systems control, or the actual awareness of BI system users and developers concerning control principles, and their opinion regarding the appeal of these principles when applied to organizations.

The objective of this study is to conduct initial exploratory research into the addressed problem, attempting to gather fundamental data and qualitative results to serve as a basis for potential further research.

To reach its objective, this study will investigate business intelligence information systems in the context of systems control and the respective users and designers of such systems along the following questions:

- Do available business intelligence software products have the necessary capabilities that are required to implement closed-loop support systems for managing organizations? This involves establishing a conceptual management control system together with its expected capabilities, and the consecutive comparison of these characteristics with capabilities of major BI products.
- Considering that not all requirements of closed-loop management control systems may be met by available BI products, are these possible shortcomings being circumvented by implementing hierarchical systems that have all the necessary capabilities, of which BI products are a part of? This item will be addressed by comparing stand-alone BI product capabilities to system capabilities of reference implementations, where the product might be used in collaboration with other software.
- What knowledge do users and designers of business intelligence information systems actually have about the principles of systems control and their application to support the management of organizations? This topic will be

covered by respective items while conducting qualitative interviews among users and designers of BI information systems.

- When being confronted with the extended capabilities of closed-loop management control systems that such systems provide in addition to standard BI product capabilities, do users and designers of BI information systems find these capabilities appealing for the purpose of enhancing organizational management tasks? This item will also be addressed during qualitative interviews with users and designers of business intelligence information systems.
- Should this research reveal that information systems for supporting organizational management based on systems control principles are less commonly deployed than expected judging from scientific and industry coverage of the topic, it would be certainly interesting to explore possible causes for this situation. While the comparison of capabilities of BI products to conceptual management control systems will expose any missing functionality, this will not suffice as an explanation for the lack of hierarchical systems consisting of multiple information subsystems that together provide the required functionalities. Thus the qualitative interviews should also address the level of process-orientation and use of top-down systems approach, as refined in the review of concepts, to investigate a potential cause for any limitation in distribution.

When dealing with the subject of control in the context of organizations and management, one must beware of the potential to cause a misunderstanding from the implied meaning of the term ‘control’. Within this study, ‘control’ is always used as a concept taken from the field of control engineering that describes the successful steering of a process to achieve a purposeful objective, while minimizing process variance and waste. Applied to the management of organizations, an information system based on control principles should support staff members in making business decisions based on reliable factual feedback data, and translate decisions into work activities in a planned and comprehensible way. In no way should using the term ‘control’ in this research imply to suggest the creation of an Orwellian surveillance system designed to monitor the activities of individuals.

1.4 Research Questions

The preceding sections have outlined the research problem of this study and described the objective of research that has been exemplified in a number of questions. In consideration of the feasibility of this study this selection of problems has to be distilled into a reasonable number of research questions.

This process of consolidation has led to the following research questions:

- Research Question One:

  Do business intelligence information systems deliver, or are being integrated into, a comprehensive management control system for organizations?

- Research Question Two:

  Would the extended capabilities of comprehensive management control systems be attractive for users and designers of business intelligence information systems?

Each research question will be covered by an individual chapter of this study, applying the respective research methods deemed to be suitable for finding an answer to the particular problem.

1.5 Contribution of Research

All over the world, a variety of factors is constantly challenging enterprises in the way they conduct business. Some of these factors are well-known and have existed since the emergence of human trade, like the urge to reduce costs and increase profit. Others are of recent origin, like the effects of globalization on businesses and the related new ways of sourcing material and work. These conceptual factors are accompanied by substantial advances in technology, especially in the area of digital information systems. Generally speaking, organizations are being pushed to reduce variance and minimize waste in their business operations by controlling their processes, and thus become ‘lean’ businesses.

Controlling production for increasing efficiency is a recognized principle in manufacturing and is widespread across the industry. Since the mid-20th century, quality management methodologies have been developed that aim at propagating the principles of control and efficiency throughout the whole organization. Businesses in the service domain also feel the pressure to the standards that have been set by manufacturing firms. After all, from the quality management point-of-view, service organizations are also production systems (Osanna, Durakbasa, & Afjehi-Sadat, 2003).

This trend is being enabled by the increasing availability of information technology that enables organizations to apply methods on service and management tasks that previously were only available to measures of production control in manufacturing.

Information technology industry analysts and software vendors are recognizing this upcoming trend, but so far there seems to have been only moderate adoption of converging business intelligence and business process management systems in the market, which is a major driver in the introduction of control principles to management tasks. Many existing efforts are focusing on corporate performance management, limited by most vendors to financial consolidation, and on monitoring the execution of present operational business processes using add-on BI tools ('Business Activity Monitoring'). These activities make only limited contribution to the objective of enhancing the support of organizational management through system control principles.

This study aims at improving this situation by contributing to related research with a number of results that should be appealing to various audiences. Initially, documenting capabilities and emphasizing the importance of control principles to organizational management at the strategic, tactical, and operational level should help both users and vendors of business intelligence systems in intensifying the implementation of such systems. To present users of BI systems, this study should reveal the level of qualification of available BI products for creating management control systems. It will also suggest the feasibility of creating such systems using a selection of various subsystems that together provide all the necessary functionality. Designers and vendors of BI systems should benefit from the increase in awareness

about the research topic among BI users. More specifically, this group will be provided with qualitative results about the attitude of users regarding management control systems, as well as the perceived effectiveness of spreading information about management control systems among their customers and staff members.

1.6 Thesis Structure

The research contained in this study was developed along the following structure:

- Chapter 1 – Introduction:
  The initial chapter of the study provides some background information and explains the research problem. It presents a number of research objectives and summarizes them into the formulation of two primary research questions which are being addressed in the main part of the study. Furthermore, it defines the key points that this study has contributed to research.
- Chapter 2 – Review of Concepts:
  This chapter offers on overview of key concepts relevant to the contents of the study. This includes general topics such as the definition of systems, quality management methodologies, and fundamentals on the control of systems. Additionally, two categories of contemporary information systems are described, along with investigating related research and scientific method.
- Chapter 3 – Research Question One:
  This chapter covers the necessary research work required for answering research question one. After establishing the research approach in the research method section, it present the results acquired from analyzing selected business intelligence vendors and their products. Subsequently, it summarizes and discusses findings induced from the research results.
- Chapter 4 – Research Question Two:
  This chapter covers the necessary research work required for answering research question two. It contains the formulation of hypotheses which provide the basis for qualitative interviews using a custom questionnaire. After describing the research method, the chapter presents the results from the evaluation of interview responses. Findings are then induced from the results and discussed at the end of the chapter.

- Chapter 5 – Conclusions:
  The final chapter opens with a reflection on the initial research objectives and provides a summary of the findings for all research questions. It also lists limitations of this study and suggests options for conducting further research into the examined topics.

1.7 Summary of Introduction

This chapter has introduced into the study by first describing the background of the research topic. Corporate investments in information technology continue to increase all over the world, and scientific and industry research demonstrate that utilizing this spending by providing an efficiency-increasing control system to non-manufacturing processes as well could substantially enhance the quality of organizational management.

A feasible solution for this challenge is the application of closed-loop system control principles to organizational management. Such a system can be realized by using available software technology such as business intelligence systems. A problem arises from the insight that contemporary BI products are not capable to fully support such a closed-loop management control system as advertised by the product vendors. There is a functional gap between expectations set through vendor communication and actual product capabilities.

This research sets its objectives to exploring the functional gap between BI products and required control capabilities, increasing the awareness of system control principles among uses and developers of BI systems, and providing more knowledge about the appeal that system control principles have among these groups. This leads to the formulation of two specific research questions, which compromise the main part of the study.

In continuing, the next chapter focuses on the review of a variety of concepts that are fundamental to investigating and answering the research questions.

2 REVIEW OF CONCEPTS

This chapter introduces important concepts and definitions by reviewing literature relevant to the research objective and research questions.

2.1 Introduction

Concepts of interest derived from the research topic originate both from the areas of engineering and management studies, encompassed by the comprehensive idea of a *system*.

Fields of engineering that are significant to this study include general systems science, control engineering, as well as information systems engineering, particularly the areas of business intelligence and business process management systems. The appropriate concepts of corporate management are being approached from the direction of quality management methodologies applied in the area of managing organizations and processes.

Together, these concepts are supporting one fundamental conception of engineering management that technical procedures are also applicable to many non-technical systems (such as the management of organizations). This interdisciplinary exchange often results in significant improvements of the non-technical system that would be difficult to achieve otherwise.

In order to put the study at hand into context with other related research, recent studies on the application of convergence of BI and BPM systems are also reviewed. Finally, the review of concepts is complemented by references to scientific methods in research.

2.2 Definitions of System and related concepts

Blanchard and Fabrycky (2006) quote the definition of a system as '… an assemblage or combination of elements or parts forming a complex or unitary whole …', which they later extend by adding the requirements of unity and functional relationships among the individual parts, and also useful purpose.

This notion is later assembled into a second, more precise and practical definition of a system:

‘A system is a set of interrelated components working together toward some common objective or purpose.’ (Blanchard & Fabrycky, 2006)

From comparing the two statements it is evident that the authors want to emphasize relationships among components and purposeful cooperation towards objectives as important aspects of any system.

Systems are made up of *elements*, which are listed as follows:

- *Components* are operating parts of a system consisting of input, processing, and output.
- *Attributes* constitute properties of the components of a system.
- *Relationships* link together multiple components and attributes.

Everything outside the system is labeled *environment*. Components of higher-order systems may be again systems themselves, which constitutes a hierarchy of systems and their *subsystems*. (Blanchard & Fabrycky, 2006)

The elements of a system always seek to fulfill a common purpose, which is named the system’s *function*. Together they employ a *process* that guides their actions towards this objective. These last-named concepts come into being only for the system as a whole and establish the important notion that a system is always more than just the sum of its parts. (Blanchard & Fabrycky, 2006)

Thinking of the objects in the surrounding world as systems has been of increasing importance in science, technology, and business over the last half-century. This is caused to a great extent by the fact that the previously dominant mode of understanding the world – *reductionism* – is ill-suited for the rising complexity of the modern world. Reductionism seeks understanding by disassembling problems into the smallest indivisible parts and thus is likely to miss functions and processes of a more complex system. This paradigm shift in the perception of the world is referred to as the transition from the *Machine Age* to the *Systems Age*. (Blanchard & Fabrycky, 2006)

This new synthetic rather than analytic mode of thinking is called the *systems approach*. It is based on the observation that the whole system does not necessarily perform well only because the performance of its parts has been perfected down to details. (Blanchard & Fabrycky, 2006)

As many other objects of scientific studies systems can also be divided into various classifications. Blanchard and Fabrycky (2006) provide some examples of such classifications:

- Natural and Human-Made Systems
- Physical and Conceptual Systems
- Static and Dynamic Systems
- Closed and Open Systems

One additional categorization of systems is the distinction between Technical and Non-Technical Systems. While Blanchard and Fabrycky equal all Human-Made Systems to Technical Systems, other sources further distinguish Human-Made Systems into Technical and Non-Technical Systems. (Kopacek, unpublished)

Given the above categories, the system of managing an organization would be classified as a human-made, physical, dynamic, open and non-technical system. In contrast, the plan how to run an organization (e.g. yearly business plan) constitutes a conceptual system. An information system that is designed to support the execution of corporate management tasks within the organization would be classified as a human-made, physical, dynamic, open and technical system.

Systems science also defines the concept of *entropy*, borrowed from thermodynamics, as being the degree of disorganization in a system. Through this concept another important objective of all human-made systems is established: to create more orderly states from less orderly states. (Blanchard & Fabrycky, 2006)

2.3 Quality Management Systems in the context of corporate management

In the late 19th century organizations and individuals in industrialized countries started to devise ways how to apply scientific and technical methods to traditional procedures in corporate management. One amongst many participants in this new

field was Frederick Taylor, who adopted the term ‘Scientific Management’ for his theories on efficient management (Taylor F. W., 2003). Later this term has been used to classify various attempts at establishing planned and organized forms of (production) management that were based on scientific and empiric methods, as opposed to traditional management techniques used by then based on rules-of-thumb, trial-and-error, and gut-level feeling.

While Taylor’s original ideas were too rigid and socially inadequate for today’s flexibility requirements in production and management, many fundamental principles are still valid in modern management concepts such as ‘Lean Production’ (Askin & Goldberg, 2008).

The significance of essential concepts of scientific management is also evident when reviewing contemporary quality management systems for corporate management. These conceptual systems are guidelines for organizations on how to set up, control, and continuously improve its management methods.

The family of ISO 9000 international standards for quality management defines in its general quality management principles references to both general systems concepts and scientific management: (EN/ISO 9001:1994, 1994)

- ‘Principle 5 – Systems approach to management: Identifying, understanding and managing a system of interrelated processes for a given objective contributes to the effectiveness and efficiency of the organization.’
- ‘Principle 7 – Factual approach to decision making: Effective decisions are based on the logical and intuitive analysis of data and information.’

In Principle 5 the notion of *effectiveness* relates to fulfillment of a purpose as established in the review of systems science, while *efficiency* basically describes the ambition to reduce entropy and create a more orderly system. Principle 7 links back to concepts of scientific management and its successors by propagating to base business decisions on empiric data as opposed to habit and gut-level feelings alone.

Another important quality management concept is ‘Total Quality Management’ (TQM), which was developed from Feigenbaum’s (1983) ‘Total Quality Control’

definition. Organizations that deploy TQM must not only control daily operations but also address strategic management in a planned way in order to deliver products and services of acceptable quality (Osanna, Durakbasa, & Afjehi-Sadat, 2003).

TQM is recognized by systems science as being a viable method for managing work within organizations in the Systems Age (Blanchard & Fabrycky, 2006).

In the definition of its major principles, TQM also refers to ideas developed from scientific management by outlining that '… statistical reasoning with factual data is the basis for problem solving and continuous improvement.' (Osanna, Durakbasa, & Afjehi-Sadat, 2003)

Another indicator given by quality management systems that corporate management is subject to the same systems principles as e.g. a physical production system are examples of process-oriented conceptual systems for creating life-cycles of management tasks. The 'Six Sigma' business and quality management method developed by Motorola Inc. (Tennant, 2001) uses a five-step 'DMAIC' model (short for Define-Measure-Analyze-Improve-Control) for guiding the development and accomplishment of corporate management. The ISO 9000 standard uses a more detailed process model that contains management-related items such as *management responsibility* (decision-making and controlling), *requirements management*, *resource management*, planning *product realization*, customer interaction, as well as '*Measurement, analysis, and improvement*' (gathering fact data for decision-making and planning for improvements) (EN/ISO 9000:2000, 2000).

While the concepts of scientific management and quality management systems have largely been implemented with focus on production systems in manufacturing, they are equally valid for the enormous field of service organizations. Service delivery does vary from manufacturing in certain aspects that need to be considered when planning and managing quality, e.g. higher degree of customization, no inventory or inspection as services are consumed as they are created (Osanna, Durakbasa, & Afjehi-Sadat, 2003). But, as identified by the authors of (Osanna, Durakbasa, & Afjehi-Sadat, 2003), '… it is important to note that service organizations are also production systems'.

When examining the control effect of business management, the common question of 'What does it mean that an item is *in control*?' should also be considered. One popular and widely accepted definition of this term has been given by Shewhart (1931), who applied his ideas to controlling the quality of manufactured goods. Shewhart reasoned that, because of the potentially indefinite number of inputs and disturbances in the universe, it must be accepted that man-made artifacts cannot be created or made to behave perfectly according to specification[1]. Instead, they will be of constant variability, yet within limits. These limits of successful control are to be set by statistical methods based on previous experiences. Consecutively, Shewhart's definition of control states that '… a phenomenon will be said to be controlled when, through the use of past experience, we can predict, at least within limits, how the phenomenon may be expected to vary in the future. Here it is understood that prediction within limits means that we can state, at least approximately, the probability that the observed phenomenon will fall within the given limits.' (Shewhart, 1931)

2.4 Control of Systems

The previous two chapters helped to establish the reason that the task of managing a production or service organization is generally equivalent to managing a system. Scientific management and its successor concepts also demonstrated that it is a feasible approach to corporate management to support it with empiric and technological methods.

A *system of management* for managing a dynamic system now must also be subject to the same principles of systems engineering: it aims at controlling the system's elements and processes towards achievement of a common objective.

What are the means of controlling a system? In the system definition by Blanchard and Fabrycky (2006) the authors identified that various system states develop from system components assuming a variety of values set by control actions. Planning and implementing these control actions constitutes the field of *control engineering* (CE).

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[1] The applied model of the universe.

As defined by Åström and Murray (2008), ‚… Control engineering relies on and shares tools from physics (dynamics and modeling), computer science (information and software) and operations research (optimization, probability theory and game theory) …‘ The principles of control systems are described as: ‘A modern controller senses the operation of a system, compares it against the desired behavior, computes corrective actions based on a model of the system’s response to external inputs and actuates the system to effect the desired change. This basic feedback loop of sensing, computation and actuation is the central concept in control.’ (Åström & Murray, 2008)

A more generalist, non-technical description of the last-mentioned control steps in the basic feedback loop is *receiving feedback* (sensing), *interpreting feedback and making a decision* (computation), and *carrying out the resulting actions* (actuation).

Another valuable characterization is given by Schmidt (unpublished), where ‘… control engineering (CE) is concerned with the engineering tasks of understanding, analyzing, and mathematical modeling of dynamic processes, as found in technical as well as non-technical object systems (also denoted as plants or processes) and of controlling the behavior of those systems …’

For the purpose of this study it has to be emphasized that CE is not to be applied only to technical systems. This important thought originates from the works of Wiener (1948) and his conception of *cybernetics*, which is the science of ‘purposeful and optimal control applicable to complex processes in nature, society, and business organizations.’ (Blanchard & Fabrycky, 2006)

Basically, a feedback loop control system consists of the following essential elements: (Blanchard & Fabrycky, 2006)

- Operating system (process):
  The system or subsystem of interest that is being controlled by the feedback control loop. Specifically, the control system controls characteristics or conditions of the guiding process that is employed to achieve the operating system’s objective.

- Output:

  The result of the operating system's function and any additional artifacts and information that may have formed during processing, especially control characteristics or conditions of the guiding process
- Sensor:

  A device or method for measuring the control characteristics or conditions.
- Input:

  Any artifacts and information that are required by the operating system for fulfilling its function.
- Controller:

  A device or method that compares planned performance of the operating system with actual performance derived from sensor measurements, and decides on the need for a control action.
- Actuator:

  A device or method that will alter the operating system based on the received control action to bring about a change in the control characteristics or conditions.

Figure 1 illustrates the elements of a feedback loop control system as described in the preceding list. Control engineering further defines the concept of *disturbance* acting on the operating system, which is not considered in the context of this study.

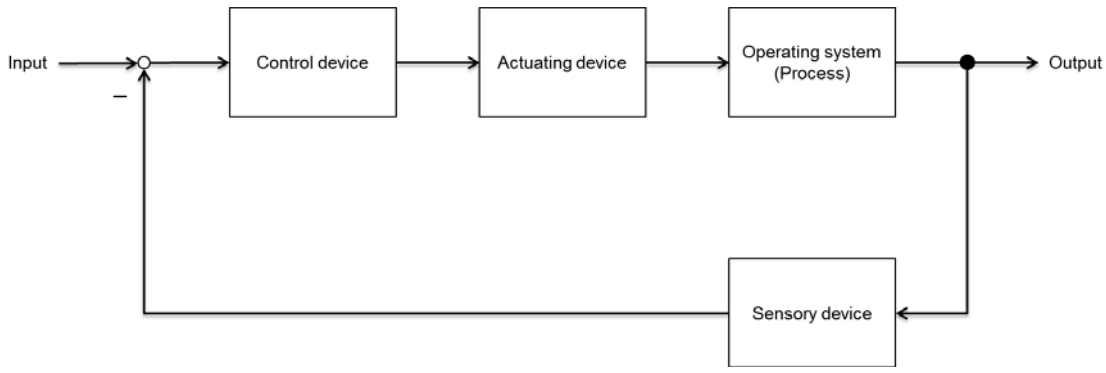

Figure 1. Elements of a feedback loop control system.

It is always necessary to assess the operating system with respect to classifications of systems and control engineering in order to derive the control system's expected complexity. Several factors determine whether the control system is required to be less or more complex.

The first selection of choices is done between an *open-loop* and *closed-loop* control system. Open-loop systems are simpler control systems, where all control decisions can be made before the system starts and do not need to be adjusted during the system's operation. In closed-loop systems, the optimal control actions can only be derived considering the systems current state, and thus require a feedback loop from the output to the controller. Another important distinction is made between *static* and *dynamic* systems. As the classification terms imply, a static system does not change with the passing of time, while a dynamic or *time-varying* system changes through motion or any other activities. The final classification used for the purpose of this study is the distinction between *deterministic* and *stochastic* systems. A deterministic system can be precisely described by a mathematical model, and thus its behavior can be exactly calculated for any point in time. In contrast, a stochastic system is characterized by also having random properties. The resulting uncertainty in the system's behavior can only be approximated using statistical methods. (Blanchard & Fabrycky, 2006)

For the purpose of this study, the control system for managing a corporation can be classified as a closed-loop, stochastic, and dynamic system.

2.5 Business Intelligence Information Systems

The term *business intelligence* has apparently been coined in an 1958 IBM Journal article by Luhn (1958), used to describe a system design for digitizing documents and distributing them to employees working in an office organization.

In 1989 Howard Dresner of the Gartner Group defined BI as '…a set of concepts and methods to improve business decision making by using fact-based support systems.' (Power, 2010)

From its very beginnings BI has always been tightly interlocked with information technology (IT) and information systems. It is an IT architecture deployed by various

organizations next to their operational information systems to overcome the common problems that arise when operational systems are used for strategic decision-making on business issues: inconsistency of related data from multiple sources, managing of user-access security, lack of integration between multiple systems, lack of flexibility in information-retrieval, and the abstraction of data from multiple formats into a common structure (Laudon & Laudon, 2010). Additionally, retrieving information for decision-making from operational information systems during business hours can severely impact their performance.

Consequentially, a business intelligence information system is a complex IS consisting of several layers of database storage, data integration processes, applications for information retrieval and analysis, as well as organizational methods for implementing and operating the system.

This complexity has meanwhile been reflected by the BI software market through the use of specialized terms for the individual layers of a BI information system. For example, Forrester Research defines business intelligence as being the *delivery layer* only consisting of information retrieval software, whereas the persistence layer storing data is referred to as *enterprise data warehouse* (EDWH), plus an additional underlying *data integration* layer for attaching the BI system to operational system data. (Kobielus, Karel, & Nicolson, 2009)

While the above split-up of terms is widely accepted in the IT business, in the context of this study the term *business intelligence* will refer to the entire information system supporting business decisions, including data warehouse storage, data integration processes and information retrieval.

From the introduced definitions, the purpose and usage patterns of a successful BI information system can be derived as such: ideally, it delivers all relevant fact information about the current state of business operations upon which corporate management can base their decisions about the future course of business.

Since the market introduction of BI information systems starting in the early 1990s the focus of information retrieval methods has been put on monitoring and performance reporting, usually implemented by means of standard reports and so-

called *ad-hoc* custom queries (Davenport & Harris, 2007). Early examples of such systems were also referred to as *enterprise information systems* (EIS). Furthermore, the context of decision-making was strategic, separated from daily or hourly decisions for business operations.

Development in recent years has introduced advanced concepts to the usage of BI information systems:

- A move towards tactical decision-making, enabled by near real-time data extraction from operational systems (Fidler, 2006).
- Intensified use of various statistical methods for advanced analysis.

The propagation of advanced statistical methods in BI led to the definition of a *BI value chain*, with increasing analytical demand from one stage to the next.

The basic stage contains *reports*, implemented as simple standard reports or interactive ad-hoc reports, optionally with drill-down capabilities from aggregated data. The next stage uses *descriptive* statistics for segmentation and clustering of data to help identify patterns and trends (partly referred to as *data mining*), where results are often displayed in an *as-is/to-be* comparison (named *key performance indicator*). *Predictive* analysis employs forecasting models and simulation to extrapolate future developments in business. Situated at the top of the BI value chain is *optimization*, which goes well beyond simple status reporting by attempting to compute and suggest an optimal course of action.

2.6 Business Process Management Systems

Organizations operate through the execution of varied activities or *business processes*. These activities can be internal, related to strategy, management, and operations, or public, which address interaction and collaboration with external parties, such as other companies. In service organizations and other non-production business environments, *business process management* (BPM) has become a synonym for the transition of paper-based work to electronic forms by supporting business processes with information systems. (Ko, 2009)

In (2010), Laudon and Laudon describe BPM as the methodology and tools required to revise and optimize organizational processes and advise to use them as fundamental building blocks of corporate information systems. Van der Aalst, et al. (2003), define BPM as ‚… supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information.‘ In his definition, Davenport (1993) further emphasizes the activity aspect of BPM in his definition of a business process as a ‘structure for action’. Yet, a business process is not a loose collection of activities, but a ‘… systematic ordering of specific work activities across time and place.’ (Ko, 2009)

In the broader sense, a business process is a sequence of orchestrated actions to achieve a common business goal in an efficient and traceable manner. In (Gartner Research, 2007), the authors also suggest that in today’s market environment agility for change is becoming more and more important in addition to efficiency.

Regardless of its existing history of over three decades, BPM has only started to become an early mainstream growing software market since the year 2006. While the current focus is on supporting operational processes, BPM can be applied to core, management, and supportive competencies of an organization at strategic, tactical, and operational levels. The key to the successful support of all these activities is the ongoing flow of information. (Ko, 2009)

When it comes to the implementation of BPM within an organization, the tools of choice are *business process management systems* (BPMS), which support the requirements of BPM with information technology. Often, this software packages are also referred to as BPM *suites* (Hill, 2010).

These software systems enable the definition, execution, and diagnosis of business processes in the organization and usually consist of multiple subsystems to provide all the required capabilities. They provide tools to analyze and diagnose current business processes, model them in a standardized format, convert the models into software programs and eventually execute them. Figure 2. Components of a BPMS (modified Hill, 2010) shows an example structure of BPMS components.

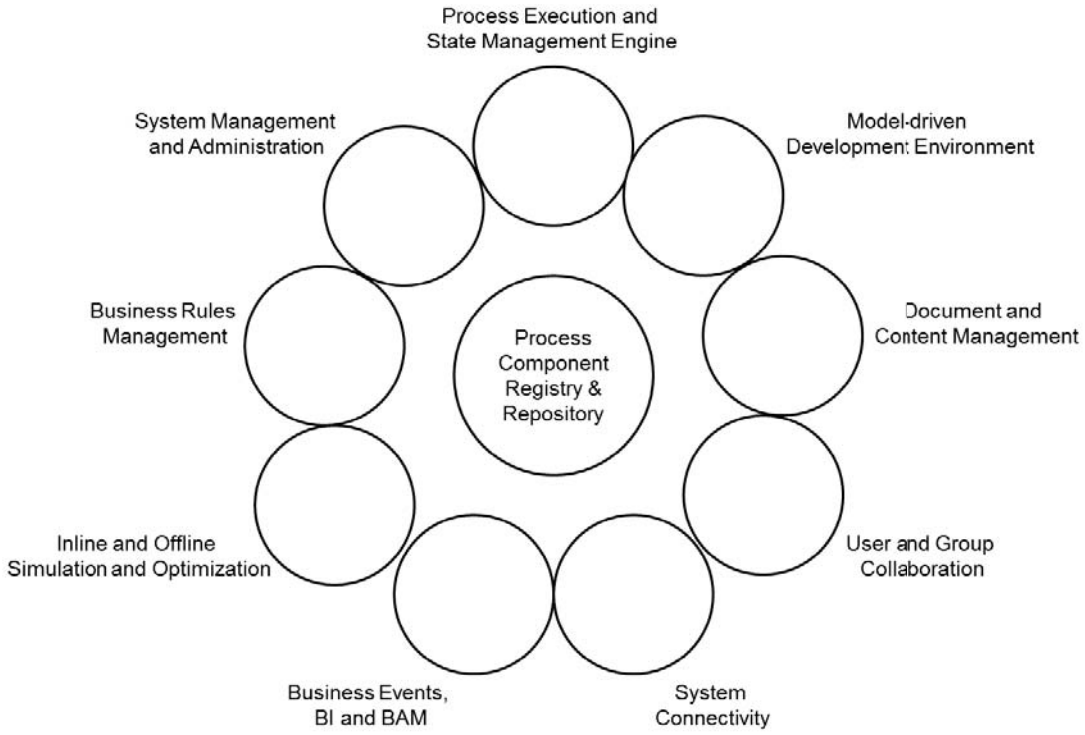

Figure 2. Components of a BPMS (modified Hill, 2010).

During the examination of BPMS, it is important to notice the subsystem of *workflow* or process execution. Workflows are an integral part of every BPMS, yet there is an ongoing discussion about the distinction of the two terms.

The Workflow Management Coalition defines workflow as being the '… automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules.' (Workflow Management Coalition, 1999) Workflow management (WfM) has been a predecessor to BPM, but according to (Hill, 2010) and (Ko, 2009), among others, lacks the analysis and diagnosis capabilities of BPMS. Additionally, WfM has been designed for internal processes of organizations and has limit flexibility for enabling cross-site or inter-company business processes. (Ko, 2009)

While workflows have been integrated into BPMS and thus became less visible as a standalone technology, they are nevertheless essential for successful BPM

implementations as the element being responsible for executing business processes as a sequence of orchestrated actions.

It is relevant for the research contained in this study that major vendors of BI information systems are often also providers of BPM suites. The comparison of industry analyst reports in the domain of BI products (Gartner Research, 2010a) and BPM suites (Gartner Research, 2010b) reveals that at least three of the top-rated business intelligence platform vendors are also offering successful BPMS products through their integrated product stack.

2.7 Related Research

For the purpose of this study, matching related research should be concerned with the convergence of business intelligence methods with business process management or workflow methods, ideally applied to the process of managing organizations. Despite the previous portrayal that workflows are merely a subcomponent of the more advanced BPM field, their capabilities are sufficient for the current research objectives. In this context, the consideration of extended BPMS components is not mandatory.

There is no doubt about the fact that the topic of converging BI and BPM/WfM has already been recognized in research and in the industry. While in (Gartner Research, 2009) Gassman and Schlegel asses that out-of-the box integration of BI and BPM is not yet available as a packaged software product, they nevertheless recommend to organizations to invest efforts into this area of rising importance. For now, implementers should deploy so-called *mashups* of best-of-breed applications to accomplish this integration of the two concepts. The objective of this proposed convergence is to embed BI-based analysis features into operational business processes, not considering the capabilities of BI for tactical and strategic management. BI components should provide real-time decision support for automated or semi-automated workflows within operational processes.

Another related field of research in the integration of BI and BPM is the concept of *business activity monitoring* (BAM). It is defined by Gassman in (Gartner Research, 2007) as a designation for the processes and technology that enable real-time, event-

driven monitoring and analysis of business process-related performance indicators. Implementations of BAM applications operate by issuing alerts about problems or changes during the execution of a business process, and they provide analysis and decision-support capabilities aimed at the respective business process through BI components such as dashboard reports, historical information, and data drill-down features. Software packages for the implementation of BAM solutions are being provided by either pure-play BAM vendors or by BI software vendors increasingly extending their offerings to also cover BAM. Many organizations are also implementing their own BAM solutions based on stock BI software.

BAM is not a full convergence of BI and BPM, it uses methods and tools from the BI information retrieval subcategory and applies them to utilize state data about the underlying business process. In this mode of operation the analysis is directly applied to operational systems, avoiding the creation of dedicated data storage layers that are specific to most BI systems (Nesamoney, 2004).

As observed by Power (2005), the emergence of BAM as a concept in information systems resembles the reinvention of BI from another direction for the purpose of real-time tracking of operational processes and raising alerts on predefined conditions, resulting in a ‘manage by exception’ approach on management tasks. This is in part driven by the attempt to continuously create ‘new’ concepts that result in tool sales in the software market. From a market-neutral academic point of view, BAM systems can simply be categorized as an example of data-driven decision support systems.

One example for a close match of related research to this study is the work of Melchert et al. (2004), who take on the concept of *corporate performance management* (CPM) coined in previous research in their examination of the convergence of BI and BPM. The authors expand their ideas from the management approach of *performance management*, which requires a close link of planning tasks to the operational execution of processes for being successful. Extending performance management, CPM has been defined as an umbrella term for ‘methodologies, metrics, processes and systems that monitor and manage the performance of an enterprise’. One of the methodologies of CPM is the required

linking of strategic goals to operational process metrics in order to control the execution of business processes.

In the definition of Melchert et al. (2004), CPM is an advancement of the BI concept, extending it by emphasizing the support of process-oriented organizations, and providing a closed loop of strategy formulation, process design, process execution, and business intelligence. It is also closely related to information systems, and the authors align CPM with three emerging trends in IT at the convergence of BI, BPM, and *enterprise application integration* (EAI): (Melchert, Klesse, & Winter, 2004)

- *Business process automation* (BPA):
  BPA aims at the automation of interactions between heterogeneous IS applications through (non-human) workflows.
- *Real-time analytics*:
  This is equal to the BI concept of *operational BI*, where information retrieval and decision-support methods used at the strategic and tactical level are moved down to operational processes by reducing the latency time between an business event and the resulting response action.
- *Process performance management* (PPM):
  PPM provides decision-support data about the performance of active business processes for the purpose of controlling the process.

From the definition of PPM it appears to meet the requirements of a management control system supporting decisions on various levels of the organization. By abstracting its mode of operation to the comparison of *as-is* states to *to-be* states in (Melchert, Klesse, & Winter, 2004), PPM even refers to the controller principle in control engineering. Yet, the authors render its tasks more precisely as measuring operational process performance and identifying opportunities for improvement (Melchert, Klesse, & Winter, 2004).

2.8 Research Design

Some parts of this study require the application of methods from social research. Thus, the necessity arises to review some key concepts of conducting such research as a preparation to the investigation of the affected parts.

As pointed out by Bailey (1994), social research commonly leads to results that are not hundred percent explainable, as opposed to scientific insight in natural science or technical disciplines. There is an ongoing discussion among social scientists whether this condition is an effect of randomness and error in the research subject or an effect of yet inadequate research techniques. In any case, it is not feasible to receive perfect explanations for the examined phenomena.

All social research projects share the common goal of further advancing the understanding of society. These projects can be realized through various research methods, including observation and experiments. Yet, one the most common forms of social research is the practice of survey research, using questionnaires and interview techniques, which is the method that will also be applied to parts of this study. The scope of survey research is the quest for correlates, sometimes even for causes. (Bailey, 1994)

As with many other conceptual constructs, also social research is a system of interdependent related stages. These stages are independent from the actual social research method and are thus also applied to studies using the survey approach: (Bailey, 1994)

- Choosing the research problem and stating a hypothesis:
  The research problem has to be clearly defined, and a testable hypothesis derived from it.
- Formulating the research design:
  Being consistent with the previously defined hypothesis, the research design formulates the detailed technique of research, including method of observation, sample consistence, and sample size.
- Gathering data:
  The required observation data is gathered through the execution of the research design that has been formulated before.
- Coding and analyzing data:
  In this stage, the gathered data is transformed and analyzed using statistical methods.

- Interpreting results so as to test the hypothesis:
  Inducing findings from the research results and applying them as a test in order to attempt to disprove the hypothesis.

For conducting social research, these stages have to be processed in the sequence displayed here. Yet, successful research cannot be accomplished without comprehensive awareness of the full process. The researcher needs to have adequate knowledge of later stages before being able to perform earlier stages in an effective way. (Bailey, 1994)

2.9 Summary of Concepts Review

Within this chapter a number of major concepts relevant for this study have been introduced, including the definition of systems, approaches to managing organizations, control of systems, as well as BI and BPM systems, two categories of information systems.

The review has revealed that the task of managing an organization can be perceived as managing a system, where the organizational system is being controlled by a management system. While some forms of management are random or based on emotions rather than factual data, there are other popular approaches that are based on empiric methods, such as modifications of scientific management and quality management methodologies. These techniques clearly reference a systems approach of thinking by being purposeful, process-oriented, consisting of multiple interrelated parts and striving to create more orderly states of the system.

If managing an organization is equal to the control of a system, the principles of control engineering can be applied to this task. Previous research in the field of Cybernetics has proven that CE concepts are also applicable to non-technical systems, such as controlling business processes within an organization.

Out of the entire spectrum of information systems that are deployed to support management tasks, BI and BPM systems are the two most commonly in use. This study is aimed at exploring the question if BI information systems are sufficient support for managing an organization, or if not rather a close interaction of BI and

BPM or Workflow systems is better capable of forming a conceptual control loop of management.

Related research shows that the topic of convergence of BI and BPM systems is being recognized in research and across the software industry. Yet, current initiatives in this area are more focused on enhancing BPM systems with add-on BI sub-modules to measure and improve performance in operational processes. They are less oriented towards the utilization of BI and BPM systems as equally important components in the support of strategic and tactical management tasks.

3 RESEARCH QUESTION ONE

Do business intelligence information systems deliver, or are being integrated into, a comprehensive management control system for organizations?

3.1 Introduction

The previous review of related concepts has demonstrated that it is a valid approach for controlling an organization to apply the principles of the control of systems in the corporate management process. At a generic level, such a management control system should provide capabilities for receiving feedback, interpreting feedback and making decisions, and carrying out the resulting actions. These capabilities can be summarized as sensing, deciding, and actuating.

As this study is targeted at the exploration of information systems, and business intelligence systems in particular, in the context of supporting management control systems, one of its main objectives must be finding the degree of coverage that BI information systems offer in the various system control categories.

The purpose of research question one (RQ1) is now to approach this research objective and attempt to answer it. Priority is given to the problem whether organizations have full support for a comprehensive management control system available by implementing a BI information system. Alternatively, the same result could also be reached by entities when the BI information system is used as a subsystem in a hierarchical system for management control. Considering the high-level product capabilities of the examined BI information systems is also of interest for covering the eventuality that, while the IS offering provides the required features, organizations have chosen not to use them in the support of management control systems.

After the introduction, this chapter briefly describes the research method applied in answering the research question. In the next section, the research method is consecutively applied to BI information systems and implementations by selected vendors, and the resulting knowledge is collected and documented. This derived knowledge is then interpreted and discussed in the subsequent section in order to

compile an answer for RQ1. A final summary section subsumes the contents of this chapter.

3.2 Research Method

For the purpose of this study, the knowledge that is necessary to answer research question one can be deduced as consequences from observation. This is possible as all the required information is already available, and findings can be concluded from this information by reasoning. Hence, it is not required to create a specialized scientific instrument for handling RQ1, although a tabular chart will be used to support the comparison of system characteristics.

The first step in arriving at an answer for RQ1 is the selection of an appropriate sample of business intelligence information systems for examination. This selection is based on popular industry analyst reports covering the area of business intelligence software and related software tools. From each of the reports that are chosen as valid sources, the three top-rated software vendors in the respective category are pre-selected. In a subsequent step, these pre-selections are compared against each other looking for consistency. The objective is to arrive at a final selection of three vendors that have stable top-of-scale ratings across all analyst reports considered.

A common name for larger-scale BI information systems in the software industry is business intelligence *platform*, and this is also reflected in the first analyst report chosen for vendor selection by Feiman and MacDonald from Gartner Research (2010a). In the ‘Magic Quadrant for Business Intelligence Platforms’, vendors having the best ratings are positioned in the upper-right ‘leaders’ quadrant, where the three top-rated products are offered by IBM Corporation, Microsoft Corporation, and Oracle Corporation (in no particular order).

A comparable report from a competing analyst firm comes from Evelson et al. of Forrester Research (2008). Its top-rated vendors in the upper-right corner segment are SAP Business Objects Corporation, IBM Cognos Corporation, and Oracle Corporation (in no particular order). The second company name added to IBM and SAP corporations is due to acquisition of previously independent vendors.

BI platform vendors have recently started to extend their offerings towards business performance management, which has also been recognized under the umbrella term corporate performance management by scientific research (Melchert, Klesse, & Winter, 2004). In consideration of this important trend that conforms to the notion of extending the support of management control by information systems, which is one of the major topics of this study, another analyst report covering *business performance solutions* (Forrester Research, 2009) is added to the vendor selection process. Its leading vendors are SAP Corporation, Oracle Corporation, and IBM Cognos Corporation (in no particular order). While the current interpretation of CPM by BI system vendors is dominated by financial planning and consolidation (Forrester Research, 2009), which is only one segment of corporate management, this result is fully factored in the vendor selection process as an outlook to future developments.

IBM Corporation and Oracle Corporation have been named by all three analyst reports and are therefore included in the vendor selection from the beginning. For the remaining third spot, SAP Corporation is named twice, whereas Microsoft Corporation is present only in one report. Therefore, SAP Corporation is selected for the remaining position in the vendor list. This decision is further justified by SAP Corporation also being represented in the leading category of the analyst report containing Microsoft Corporation (Gartner Research, 2010a).

For the remaining research efforts concerning RQ1, the company and product names from the vendor selection will be made anonymous in a simple way by referring to them as vendor/product A, B, and C. This is to substantiate the intention of this study that it is not focusing on the comparison of individual vendors against each other, but rather on a generic comparison of state-of-the-art BI information systems versus expected capabilities of management control systems.

The selected BI product from IBM Cognos Corporation was *IBM Cognos 8 BI*, and the following sources have been used in the evaluation: (IBM Corporation, 2008a), (IBM Corporation, 2008b), (IBM Corporation, 2009a), (IBM Corporation, 2009b), (IBM Corporation, 2009c), (IBM Corporation, 2009d), (IBM Corporation, 2010).

The selected BI product from Oracle Corporation was *Oracle Business Intelligence Enterprise Edition 11g*, and the following sources have been used in the evaluation: (Eckerson, 2009), (Buytendijk & Landry, 2009), (Oracle Corporation, 2009a), (Oracle Corporation, 2009b), (Oracle Corporation, 2009c), (Oracle Corporation, 2009d), (Oracle Corporation, 2010a), (Oracle Corporation, 2010b), (Oracle Corporation, 2010c), (Oracle Corporation, 2010d), (Taylor J. , 2010).

The selected BI product from SAP Corporation was *SAP Business Objects XI 3.1*, and the following sources have been used in the evaluation: (SAP AG, 2008), (SAP AG, 2009a), (SAP AG, 2009b), (SAP AG, 2009c), (SAP AG, 2009d), (SAP AG, 2009e), (SAP AG, 2009f), (SAP AG, 2009g), (SAP AG, 2010).

Arriving at results from RQ1 will be realized in two consecutive research steps for each vendor. First, the purpose of the BI information system as communicated by the vendor when setting customer expectations will be evaluated considering general principles of corporate management and control systems from the concept review chapter. This is done in order to assess the vendor's own view if and to what degree the product supports a management control system or should be included in a hierarchy of systems providing that support. In the second step, the product's features and the functionalities used with reference implementations will be compared against a list of proposed characteristics of a conceptual management control system (CMCS). This comparison provides the answer to the question if the product is capable to support a comprehensive management control system, and if it is being utilized to fulfill that role in actual implementations, either stand-alone or as a part in a hierarchy of systems.

The comparison tool, as presented in Table 1, is used to document the results of comparing proposed characteristics of a conceptual management control system against stand-alone characteristics of the BI software product and characteristics of reference implementations, where the BI software product might be used in a hierarchical system together with other subsystems.

Table 1. CMCS Characteristics Comparison.

Conceptual Management Control System Characteristics	BI Product Characteristics	Reference Implementation Characteristics
Level of Management		
Strategic	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Tactical	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Operational	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Sensor		
Operating System Feedback Measurement	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Controller		
Fact-based Decision Support	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
As-Is/To-Be Comparison	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Predictive Decision Support	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Computing Optimized Corrective Action	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Decision-Making Automation	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Actuator		
Operating System Change Effecting	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Process Flow Automation	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*

The comparison criteria are divided into four segments, measuring the management level the system is suitable for or being utilized with implementations, and the three basic elements of the feedback control loop, being sensor, controller, and actuator. Each of the criteria is using the same four-step scale for measuring results.

3.3 Results from Research Question One

This section of the study presents the results for research question one for each of the selected vendors.

3.3.1 Vendor A

The BI message communicated by vendor A very quickly gets into feature details of the various reporting and analysis styles provided by the product. Looking for a positioning statement on the vendor's vision about business intelligence, the first to be encountered is the principle of factual approach to decision-making, which is also defined by quality management methodologies (EN/ISO 9001:1994, 1994). Vendor A introduces this topic by advising not to base business decisions on 'gut feel', and postulates that informed decisions are decisions that are based on solid data and adequate analysis. In a short summary statement, the vendor equals business intelligence to the comprehensive access to decision-quality information.

For most of the remaining definition of business intelligence vision, the predominant topic is business strategy. The BI product is introduced in the context of the task to align strategic goals with daily operations. It can support this intention at both the strategic and operational levels of management. At the strategic level, BI is to support the business planning process as well as provide reporting and analysis capabilities for budgeting and statutory and management reporting. Another related reference indicates at the benefits of aligning and connecting multiple organizational strategies in a closed loop system. At the operational level, BI enables operational management to identify trends in day-to-day business, simulate scenarios for decision-making, and adopt resulting corrective actions to effect the decision into operations.

This alignment of business strategy to its execution is often labeled *business performance optimization* by vendor A, sometimes also referred to as *closed-loop* business performance optimization. This conceptual model is divided into four steps, which can be linked to the three phases of system control (sensing-computation-actuation). Vendor A models the computation phase as two consecutive steps, *strategy* and *decisions*. At another point in the product information material, a related concept is named *End-To-End BI*, which also enables management at various levels to identify causes of present developments and devise appropriate solutions. Apparently, the concept of business performance optimization is related to CPM, as discussed by the authors of (Melchert, Klesse, & Winter, 2004). In contrast to CPM

interpretation by many other vendors, vendor A does not limit its scope to financial planning and consolidation. Apart from these two must-have functions, with vendor A the term also includes risk mitigation, compliance, monitoring, and measuring operational performance.

Finally, two other aspects of business intelligence as provided by vendor A that are related to business processes are worth mentioning: introducing BI will improve agility within the organization, which has been identified as an important trait of BPM by the authors of (Gartner Research, 2007), and the possibility to embed the analytic functionality within business processes themselves. The results from comparing CMCS characteristics to vendor A's BI product are documented in Table 2.

Table 2. Vendor A Characteristics Comparison.

Conceptual Management Control System Characteristics	BI Product Characteristics	Reference Implementation Characteristics
Level of Management		
Strategic	*Strong*	*Weak*
Tactical	*Strong*	*Strong*
Operational	*Weak*	*Weak*
Sensor		
Operating System Feedback Measurement	*Strong*	*Strong*
Controller		
Fact-based Decision Support	*Strong*	*Strong*
As-Is/To-Be Comparison	*Strong*	*Medium*
Predictive Decision Support	*Strong*	*Weak*
Computing Optimized Corrective Action	*None*	*None*
Decision-Making Automation	*None*	*None*
Actuator		
Operating System Change Effecting	*None*	*Weak*
Process Flow Automation	*None*	*None*

The BI product supplied by vendor A contains all necessary functionality to comprehensively support decision makers at the strategic and tactical levels. While it is also possible to implement decision support at the operational level of management, the reviewed product documentation did not indicate at any specific functions for this area of use. With reference system implementations, the product is being strongly utilized for tactical management tasks, and has only limited coverage at the strategic and operational level.

Sensing capabilities for measuring feedback from the operating system are vital to every business intelligence product, and vendor A's solution covers this area well in both product characteristics and actual implementations.

Vendor A's BI product has strong capabilities at the basic to advanced levels of decision support functionality, up to the application of forecasting activities. The examined documentation provided no indication of the availability of high-level functionality such as optimization. There has also not been any sign of support for decision-making automation. With the sampled reference implementations used for examination, there is a strong tendency to realize less-complex decision support solutions. While basic fact-based reporting is heavily utilized, other decision support functionality is less often deployed with increasing complexity. Additionally, there are no references in the examined material towards optimization or attempts of automation of decision-making, which could have been provided by other products in a hierarchy of systems.

Although vendor A's does not provide any information about the change effecting capabilities of the BI product, the reference implementation material contains signs of basic integration with BPMS-based processes. As with decision-making automation, the examined material does not indicate any management process automation.

3.3.2 Vendor B

In one of the initial messages concerning the purpose of BI, vendor B establishes a well-known principle of BI as providing information to people for better decision-making. This basic proposition is followed by several modes of usage that are

available to customers of the vendor's BI software: setting targets and comparing them to results, identifying and analyzing trends, as well as taking action with a common decision-making context across every department. In another reference, the vendor describes the system as offering options (together with a data warehouse system from the same vendor) for deeply looking at information patterns and trends, acting quickly based on business insight, and improving productivity. A different source contains the vendors proposed business requirements that a state-of-the-art data warehouse system (included in the study's BI definition) needs to meet: optimizing strategic and tactical decision-making, and accessing, analyzing, and acting upon key business information.

This selection of BI system descriptions contains multiple cases of accordance with quality management methodologies and principles of scientific management. Besides the fundamental doctrine of basing decisions on factual information, repeated entries on trend identification and analysis points towards Shewart's (1931) finding of the need to predict future variance considering preset limits as a way to exercise control. The reference to productivity improvement can be transformed to the call for effectiveness and efficiency contained in ISO 9001 principles. Furthermore, quoting strategic and tactical decision-making is evidence that the system is targeted at these higher levels of management, not only operational decisions. The system descriptions also point to characteristics of control systems by proposing the sensing of the current system state through accessing information, analyzing sensor readings through *to-be/as-is* comparison to make a decision, and acting upon the decision taken.

The information about the BI system provided by vendor B also indicates through multiple quotes that the vendor acknowledges the concept of its BI system being a subsystem in a hierarchy of systems supporting corporate management. The possible alignment of strategy and operations across multiple business departments, applications, and strategic plans is specified as one of many benefits of the BI system. One passage in the text explicitly mentions the automation and semi-automation of decision-making and integration with business process management.

Also noticeable from the examined material is the frequent mentioning of *performance management*. As discussed in the research method section, vendor B follows the industry trend by placing its implementation of this concept at financial planning and consolidation, somewhat limiting the broad spectrum of CPM. One remarkable quote envisions the inclusion of the vendor's BI system in the creation of a *closed-loop* performance management system that integrates BI and planning capabilities.

Table 3 illustrates the results from comparing vendor B's BI product and reference implementations to proposed CMCS characteristics.

Table 3. Vendor B Characteristics Comparison.

Conceptual Management Control System Characteristics	BI Product Characteristics	Reference Implementation Characteristics
Level of Management		
Strategic	*Strong*	*Weak*
Tactical	*Strong*	*Strong*
Operational	*Weak*	*Medium*
Sensor		
Operating System Feedback Measurement	*Strong*	*Strong*
Controller		
Fact-based Decision Support	*Strong*	*Strong*
As-Is/To-Be Comparison	*Strong*	*Strong*
Predictive Decision Support	*None*	*Medium*
Computing Optimized Corrective Action	*None*	*Weak*
Decision-Making Automation	*Medium*	*None*
Actuator		
Operating System Change Effecting	*Weak*	*Medium*
Process Flow Automation	*Weak*	*Weak*

From the product documentation provided by the vendor it was evident that the BI platform is well suited to be applied in the areas of both strategic and tactical management, while the stand-alone product lacked specific components for supporting operational management tasks. With reference implementations, the focus shifts noticeably from the strategic side to operational use.

Unsurprisingly, product capabilities and their utilization are both strong in the category of measuring feedback information from various sources.

Both built-in decision support capabilities provided by the product, fact-based reporting and as-is/to-be comparison, are being adequately applied in all of the reference implementations. With increasing complexity of controller decisions, predictive decision support and optimization, examples of their implementation are becoming rarer. Yet, the occurrence itself of the two latter categories which are not included in the stand-alone product indicates the adoption of a hierarchy of systems approach with implementations. The support for rule-based automation of decisions provided by the product is not being used in any of the examined reference cases.

In the actuator category, the rating recognizes the product's compatibility for integration with process flows governed my business process management systems, although the workflow or process management component is not part of the product itself. While this capability is not yet being used comprehensively judging from the examined material, there are cases of its application in the reference implementations, one case even attempting to create a complex integration of the BI system with a supply chain management system.

3.3.3 Vendor C

Vendor C's introductory communication about its BI product portfolio is dominated by the notion of unifying business intelligence and performance management. This should provide its customers a state of management excellence, achieving competitive advantage and leveraging costs. As a consequence, it is very clear from the start that the vendor has recognized the benefits of linking together planning and operational processes. The vendor also sets further expectations by announcing the

provision of an integrated system for managing and optimizing performance to its customers.

Another frequently used specification is the product's capability to address various levels of management tasks, stated as strategic, financial, and operational management processes. The use of the financial level hints at the vendor's interpretation of performance management as being equal to financial management, although the product portfolio also contains packaged applications targeted at customer relationship or human resources performance management. While the level of tactical management appears to be missing, further examination of the source material reveals that this type of management tasks has apparently been divided and included in the strategic and operational management categories.

Throughout the observed source material, vendor C makes continuous references to the concept of processes. This is a sign of process-oriented and systemic thinking, following the values of quality management methodologies and the conception of an organization as a system of interrelated processes. Consequently, it sets the expectation that the BI product also supports these principles.

Another important topic in the vendor's communication on BI, which is given considerable coverage from early on, is the ability of the product to interact with workflows and business process definitions directly out of reports and analysis results. The documentation states that it is possible to turn analysis results into management actions by invoking business processes from BI dashboards and reports. Extending this basic functionality is the added support for real-time decision management, which according to the vendor combines business rules and predictive analysis for decision-making in operational processes. This product feature is described as supporting both recommendations by the system to decision makers as well as fully automated decisions. Generally, vendor C is positioning the offerings with regard to using BI in operational processes between two end points of a scale: using BI to assist people responsible for managing and executing business operations, and managing operational decisions through automation based on rules and analysis results. In another piece of source material, this integration of BI analysis and

operational applications is referred to as *closing the loop*, which is a matching expression to the principle of feedback-loop control.

The comparison characteristics for vendor C's BI product relating to the conceptual management control system are represented in Table 4.

Table 4. Vendor C Characteristics Comparison.

Conceptual Management Control System Characteristics	BI Product Characteristics	Reference Implementation Characteristics
Level of Management		
Strategic	*Strong*	*Weak*
Tactical	*Strong*	*Strong*
Operational	*Strong*	*Medium*
Sensor		
Operating System Feedback Measurement	*Strong*	*Strong*
Controller		
Fact-based Decision Support	*Strong*	*Strong*
As-Is/To-Be Comparison	*Strong*	*Strong*
Predictive Decision Support	*Medium*	*Strong*
Computing Optimized Corrective Action	*None*	*None*
Decision-Making Automation	*Strong*	*None*
Actuator		
Operating System Change Effecting	*Weak*	*Weak*
Process Flow Automation	*Weak*	*Weak*

Vendor C's BI product shows a strong coverage of the strategic and tactical levels of management, which are the common focal points for business intelligence, and also makes extra effort to support operational management tasks through real-time integration and analysis and similar initiatives. With reference system implementations, these efforts are acknowledged by a solid number of operational

management support systems, next to the strong level of tactical decision support. BI for strategic decision support had only limited presence in the sampled case studies.

Measuring operating system feedback is a fundamental function of BI systems and therefore shows up strong on both product characteristics and application in the field.

Expectedly, the BI product is strong in the two less complex decision support categories of fact-based reporting and as-is/to-be comparison, which also covers descriptive analysis and data mining. These functionalities are also strongly utilized with implementations of management support systems. The product as well contains significant functionality in the area of predictive decision support, and almost every reference case included in the evaluation sample is applying this forecasting ability. While optimization is not included as a product feature, this sophisticated management control function could have been supplemented by additional software products in the implementation of a system. This has not been the case in any of the references selected for evaluation. Furthermore, vendor C's product includes significant decision automation functionality based on business rules and analysis results, and this is also adequately communicated in the provided product information material. Yet, none of the sampled implementations has utilized this advanced functionality.

As found with other reviewed products, vendor C's BI product contains all the necessary technical interfaces for integrating analysis results with workflows or business processes, including the opportunity for process automation, and thus allowing to establish a closed loop of management control. But while the evaluated system implementations documented a significant number of decision support on the operational level, almost none of these cases reported a closed integration of decision-making and action effecting. The two activities were kept separated by management control actions not defined within an information system.

3.4 Discussion of Findings from Research Question One

Following the descriptive comparison of BI product characteristics against expected characteristics of a conceptual management control system, this section now discusses and attempts to interpret the findings from answering research question one.

Vendor A's BI communication puts business strategy into the foreground, and also emphasizes the need to align strategy with business operations. After managerial planning and reporting, business intelligence should support, among other tasks, the adoption of resulting actions in business operations. This strategy-operations alignment is also referred to as closed-loop business performance optimization, a model that is described consisting of system control phases related to the sense-compute-actuate control phases from control engineering. While vendor A puts less accentuation then comparable vendors on actual integration of BI with workflows or BPM in the examined product documentation, it is evident that in an overall view, BI is positioned to be part of a management control system that extends beyond feedback measurement and basic decision support.

From the comparison of BI product characteristics to CMCS characteristics it is apparent that vendor A's BI product does not include all the required functionality for creating a closed-loop management control system, especially in the actuator section and complex decision-making items. This is somewhat expected, as major information systems vendors offer a stack of application software where functionalities a distributed across the stack. It does not imply that vendor A's BI product is not suitable for being a subsystem within a closed-loop management control system, but only answers the first part of RQ1 that the standalone product has insufficient features for delivering a comprehensive management control system. Vendor A's communicated BI vision sets the expectation that such solutions would be presented by reference implementations, where the BI product is merged with other subsystems.

Surprisingly, this assumption is not confirmed by the reference implementation material sampled for examination. There are no documented traces of a system that supports closed-loop management control. On the contrary, controller activity in reference implementations quickly diminishes with increasing decision support complexity, and there is no reported actuator activity, except a single case of loose interaction with an enterprise resource management system. Additionally, the low number of business strategy decision support is odd compared to vendor A's strategic positioning of BI. To answer the second part of RQ1, BI product A is not being

integrated into comprehensive management control systems, or vendor A is not documenting this in the provided reference case material.

Compared to vendor A, vendor B is positioning business intelligence equally for strategic and tactical decision-making in management, and not emphasizing strategy alone. Additionally, vendor B repeats the necessary alignment of strategy and operations through BI, covering the operational part of business as well. This vendor also sets the expectation that the concepts of control systems are understood and supported by the BI product. Indicators for this presumption are descriptions of a three-step BI cycle of accessing, analyzing, and acting upon business information, as well as the concept of BI as a means to support control execution by predicting variances in business processes. Vendor B also positions its BI product as a subsystem within a hierarchical system that is supporting corporate management by providing a closed-loop performance management system. With additional portrayal of functionality for the automation or semi-automation of decision-making, and the integration of product B with BPM systems, the perception is justified that the product enables customers to create a management control system.

Again, not every characteristic of the conceptual management control system is covered by product B's built-in capabilities. It lacks decision support functions above mid-level as-is/to-be comparison due to another software application from vendor B's stack is covering this part. The product does contain medium-level decision automation capabilities and interfaces to BPM systems, altogether demonstrating the ability to utilize the BI product for supporting closed-loop management control. The answer the first part of RQ1, product B cannot solely deliver a comprehensive management control system, but is well positioned to enable such a system in a hierarchical system.

With reference implementations of product B, there is significant indication that the controller capabilities of the product are being enhanced with advanced decision support functions through additional software applications, sometimes even adding high-level control activities such as optimization of corrective actions. This supports the assumption that advanced decision support capabilities are necessary for the control of a stochastic system such as managing an organization. The promising

feature of supporting decision-making automation is not used in any selected reference case, but it is not a mandatory feature of management control. The interfacing capability to workflow and BPM systems is being utilized in almost half of the examined implementation cases, which is a promising sign for future developments in the field of building closed-loop management control systems. Even the sophisticated automation of process flows is applied to effect changes within a supply chain management system as a result of management decisions. Again, similar to vendor A also product B shows only limited use at the strategic level of management. One interpretation is that this is not a sign of limited product capabilities, but rather a consequence of the observation that organizational managers responsible for strategic decisions are less regular users of information systems. In an isolated consideration of vendor A, the BI product would positively answer the second part of RQ1 in that it is being integrated into implementing a closed-loop management control system in a number of cases. However, this result is limited by the fact that the management control systems described in the reference cases are applied to selected business processes of the organization, and not used to support the management of the organization as a whole.

Vendor C presents its business intelligence vision as an intention to link strategic planning within an organization with its operational processes. In the reviewed documentation, this attempt is recognized under the principle of ‘closing the loop’. Comparable statements are also found in the materials provided by vendors A and B, and are a reliable evidence of the vendor’s acknowledgement of utilizing control principles for managing organizations. According to vendor C, the successful linking of operational processes is realized by the unification of business intelligence and performance management, and the vendor announces its BI product to be part of an integrated system for managing and optimizing performance. Furthermore, there is a significant level of information regarding process-orientation in the examined BI material, which is enhanced by the vendor’s proclamation that the BI product includes substantial support for interaction with workflows and BPM systems, and even contains capabilities for implementing automated decisions. The expectations are set that BI product C empowers organizations to create process-oriented closed-

loop performance management systems, which should be widely conforming to the characteristics of a management control system.

BI product C shows strong capabilities across all considered levels of management, its controller activities extending into the mid-levels of decision support capabilities. Again, as also considered in the discussion of BI products A and B, any advanced decision support capability not included in the BI product is expected to be provided by additional software applications from the vendor's product stack in reference implementations. In contrast to the previously reflected BI products, product C has extended capabilities for rule-based decision-making automation. Additionally, it also contains interfaces for integration with workflows and BPM systems. Because native workflow capabilities are missing in the BI product, it would not deliver a comprehensive management control system as a stand-alone solution as defined by the first part of RQ1.

With the examined reference implementations sampled from provided information by vendor C, there is a repeated pattern of utilization across the different levels of management. While there is expectedly strong to medium use for tactical and operational purposes, the strategic level is only weakly covered. An interpretation of this pattern was already given in the discussion of vendor B. Considering controller activities, there is an even distribution of applying the various decision support capabilities provided by the BI product. The advanced predictive decision support functionality is regularly used in reference implementations, leading to a strong rating in this category. Unfortunately, optimization and automation of decision-making where not reported to be used in any of the sampled implementation examples. Furthermore, there were only a limited number of cases hinting at the integration of BI product C with workflows or BPMS for creating a closed-loop performance management system. As observed with vendor B, these limited cases were also applied to specific business processes, and not to provide a comprehensive management control system for the organization as a whole. The outcome for this is that regarding the answer to the second part of RQ1, BI product C is not significantly being integrated into comprehensive management control systems for organizations.

In an overall view, reasoning from the examined examples of BI products, contemporary implementations of BI systems are clearly falling short of fulfilling the advanced visions promised by their vendors. They offer strong sensor capabilities for measuring operating system feedback, and also provide basic to advanced levels of decision support functionality for controller activities. However, there is no significant evidence of substantial closed-loop system implementations, which require the adoption of actuator activities through workflows and BPM systems, and would also be expected to show examples of optimizing corrective actions and at least partial automation of decisions and process flows.

3.5 Summary of Research Question One

This chapter was dealing with answering research question one as defined at the beginning on the chapter. After a short introduction, it presented the research method that would be applied to the treatment of this problem. Because the required knowledge was already available, a method of deducing consequences from observation has been used. Additionally, the selection method for vendor comparison has been explained, along with listing reference material sampled for the examination.

Following the description of the research method was a comparison of BI products by three selected vendors against a definition of characteristics of a conceptual management control system. After reviewing possible expectations that vendors create through communicating BI vision and product capabilities, it has been revealed and later discussed that contemporary BI implementations are not capable to deliver a comprehensive system for supporting management control on their own. There is also only limited evidence of such control systems being successfully created by integrating BI systems into larger hierarchical systems that would achieve this objective.

In the next chapter, this study now continues with an exploration into possible causes for this absence of significant numbers of cases that would implement management control systems in organizations using information systems. In this context, research question two will focus on the question whether the extended capabilities of such

management control systems are attractive at for users and designers of BI information systems.

4 RESEARCH QUESTION TWO

Would the extended capabilities of comprehensive management control systems be attractive for users and designers of business intelligence information systems?

4.1 Introduction

From the criteria comparison covered by RQ1 in the previous chapter it is evident that contemporary BI products do not possess all the required capabilities to deliver a system supporting closed-loop management control in organizations. Considering the abundance this topic is receiving in analyst reports and vendor marketing information, the low number of actual closed-loop control systems documented is somewhat surprising. Even the extension of the object of study in this research to equivalently include control systems created from a variety of mixed information systems did not significantly increase these low numbers.

What could be possible causes for this lack of a significant number of successful management control system implementations? The simplest explanation for this phenomenon has already been revealed in the investigation of RQ1 – insufficient capabilities of available BI products. Yet, this solution has to be rejected due to the possibility of creating hierarchical systems that would deliver the expected functionality for managing organizations. Review of available systems in sections 2.5, 2.6, and 2.7 has shown that the required technical functionality is readily available.

Other causes must be responsible for the observed situation. In contrary to published belief, are the extended capabilities of comprehensive management control systems as compared to traditional BI systems attractive for users and designers of BI systems? Does this group have sufficient knowledge about the benefits of control principles, and do they receive the information about this topic provided by analysts and vendors? Is the implementation of management control systems influenced by certain organizational structures? Covered in this chapter, the results of research question two (RQ2) should indicate at advanced explanations for this problem by finding or rejecting correlation to a variety of factors.

The first step in finding results for RQ2 is the formulation of hypotheses serving as a guideline for consecutive stages. Hypotheses will be developed addressing the outlined areas of interest of RQ2, and referring to the review of concepts and findings of RQ1.

This is followed by the description of the applied research method. For RQ2, this consists of inducing consequences from the hypotheses and designing a survey questionnaire that is testing for the opposite of these consequences. The research method section also contains a supplemental definition of the survey target group and its mode of execution.

After conducting the survey, its results are presented grouped into the different sections of the questionnaire. Within each section, both the quantitative results, such as average responses and agreement tendency, as well as the qualitative explanations for the responses provided by the interviewed persons are shown.

The subsequent discussion of findings for RQ2 summarizes the previously assembled responses and gives an interpretation of the results.

4.2 Hypotheses

A number of interesting questions have resulted from the examination of research question two. Before proceeding with further research, these problems have to be related to previous insight presented in the concepts review and the findings from research question one and formulated as hypotheses.

It is evident from section 2.5 that business intelligence systems are widely-used in contemporary organizations. Except for the smallest of corporations, it is vital for every business organization to have a clear picture of its actual state of business, and enhance this standard reporting with advanced statistical methods that provide insight to hidden information and forecasts into the future. Using BI information systems has become a de-facto standard for supporting fact-based decisions. While being adopted by organizations only recently as compared to BI systems, business process management systems that were introduced in section 2.6 are growing in importance, especially for larger, more complex enterprises. BPM systems provide their organizations with the capability to plan, document, and execute their

operational processes in a consistent and traceable way. As such, BPM systems and the 'light-weight' workflow systems show great promise to become the fundamental technology that every organization is using to control their work activities. In section 2.3, it has been established that since the 19th century, corporations have attempted to introduce planned and organized forms of management that were based on scientific and empiric methods. This counter movement to traditional decision-making based on rules-of-thumb has developed itself further into contemporary quality management methodologies and similar guidelines, which propagate a systems approach and fact-based decision-making for effective and efficient control of organizations. Judging from this ongoing ambition to reduce variance and waste in the management of business, and the successful adoption of information systems that support this objective, it can be induced that the capabilities of closed-loop management control systems must also be attractive for organizations. Thus the respective hypothesis can be stated as follows:

Hypothesis 1: Designers and users of business intelligence systems find the capabilities of closed-loop management control systems attractive for using them in managing organizations.

Section 2.7 of this study presented an overview of related research, concerned with the convergence of business intelligence methods with business process management or workflow methods. Through related works, industry analysts support the notion that closed-loop management control systems can be realized using a best-of-breed approach from available information systems. Yet, the remaining research examined in section 2.7 revealed that other efforts are more targeted at implementing information systems to measure operational process performance and identifying opportunities for improvement, as opposed to providing comprehensive control systems supporting the management of organizations. Additionally, the research covered in chapter 3 discovered that there is only an insignificant ratio of attempts to create closed-loop management control systems compared to traditional BI implementations, despite measurable information-spreading efforts by BI vendors and industry analysts. With this in mind, it is a valid conclusion to assume that designers and users of BI information systems have still insufficient knowledge about system control principles, and market communication from vendors and

analysts does not effectively reach its audience. This can be stated through the following hypothesis:

Hypothesis 2: Designers and users of business intelligence systems do not have sufficient knowledge about the principles of systems control and their application for managing organizations, as outlined by BI vendors and industry analysts.

References examined in section 2.6 have confirmed that major vendors of BPM software systems are also providers of leading BI information systems. As such, its staff members trained in the offerings of the product stack must be able to effectively consult potential customers on the implementation of a best-of-breed management control system, as suggested in section 2.7. Additionally, well-informed staff at customer organizations must also be capable to recommend the utilization of available software from a known product stack to create such systems. If hypothesis 2 proves wrong and there is enough information about control principles among users and designers of BI systems, other factors within vendor and customer organizations must correlate with the low adoption rate of closed-loop management control systems. Even if hypothesis 2 is confirmed, this other factors can become effective once sufficient knowledge has spread. Reversing the characteristics of the systems approach as described in section 2.2 and applied to quality management methodologies as shown in section 2.3 leads to the definition of strict vertical organizational structures, and lack of process-orientation and top-down systems approach as such factors. The respective hypothesis can be stated as follows:

Hypothesis 3: Product-centric vertical organization structure and the lack of process-orientation and top-down systems approach are factors causing the limited adoption of closed-loop management control systems.

4.3 Research Method

The research in RQ1 induced consequences from present knowledge taken from available materials. For RQ2, the focus of research lies in retrieving the opinion of BI system professionals, both users and designers, on their perceived state of BI and control systems in order to test the three hypotheses formulated in the previous section. Furthermore, the objective of this part of the exploratory study was set to

aim for qualitative results, achieving a quick result that would indicate possible directions for additional research. Based on these requirements, the classic method of conducting a survey was selected for the research approach. The survey instrument would be a custom questionnaire consisting of multiple sections, each one designed to test one of the RQ2 hypotheses or provide additional detail results. Another criterion for selecting this research method was the feasibility of access to BI professionals by the study's author. Conducting the survey in a series of personal interviews based on the questionnaire would also result in a high response rate, as compared to mailing the questionnaire to multiple recipients.

The custom survey questionnaire was designed to consist of five sections. The full research instrument is listed in Appendix B.

The questionnaire starts with a short introduction explaining the mode of answering the contained questions, a confidentiality statement, and the intended use of the received results. This is followed by the first section consisting of six questions asking about demographics and professional background of the interviewee. This includes questions for age, gender, and years of professional experience, as well as the typical size of organizations where the professional has acquired BI systems experience, based on the number of employees.

The second section is labeled 'Attitude towards closed-loop management support capabilities' and is assigned to hypothesis 1. Working from the hypothesis statement, the following consequences and behavior has been induced if hypothesis 1 is assumed to be true:

- Professionals believe that corporations do benefit from conducting work based on factual decisions and defined processes.
- Professionals believe that using information technology to link decision-making to resulting work activities significantly increases efficiency.
- Professionals believe that difficulties in the execution of management tasks would be improved by using a closed-loop management control system.
- Professionals would support the implementation of closed-loop management control systems.

The survey questions in section two are designed to test for the opposite of these consequences. If this test returns false, it can be assumed that hypothesis 1 is true until falsified by future research.

The third section of the questionnaire has the title 'Attitude towards extending the capabilities of contemporary BI information systems'. It is not associated directly with any of the three hypotheses, but asks professionals about their attitude towards extended capabilities of closed-loop management control systems in comparison to capabilities of present BI information systems. These extended capabilities relate to the advanced items of the comparison instrument used for RQ1 that is presented in Table 1. The following characteristics are queried in section three: predictive decision support, computing optimized corrective action, decision-making automation, operating system change effecting, and process flow automation.

The subsequent fourth section of the questionnaire is titled 'Satisfaction with information received or acquired on systems control principles in BI management support'. This section relates to hypothesis 2 and investigates the amount of knowledge professionals have about new trends in BI, especially control principles, in order to use them in the creation of new management support systems. For this purpose, the following consequences and behavior has been induced from hypothesis 2 if it is assumed to be true:

- Professionals do not sufficiently perceive the information regarding system control principles for BI management support created by vendors.
- Professionals do not allocate adequate time to inform themselves about industry analyst reports regarding new trends in BI management support.
- Professionals believe that reference cases and usage scenarios published by vendors to inform about BI information system capabilities are being ignored by organizations.

The survey questions in section four are designed to test for the opposite of these consequences. If this test returns false, it can be assumed that hypothesis 2 is true until falsified by future research.

The remaining fifth section of the survey questionnaire is labeled 'Factors influencing the adoption of BI management support systems based on system control principles'. The questions in this section are associated to hypothesis 3. Assuming that hypothesis 3 is true, the following consequences and behavior can be induced:

- Professionals experience their typical work environment as having a product-centric vertical organization structure.
- Professionals are able to apply a top-down system approach only in a minority of cases when implementing BI management support systems.
- Professionals believe that there is not sufficient inter-departmental cooperation within their organizations to support the convergence of BI and BPM systems.

The survey questions in section five are designed to test for the opposite of these consequences. If this test returns false, it can be assumed that hypothesis 3 is true until falsified by future research.

The survey was conducted in a series of interviews during October and November 2010. Each candidate required between 30 and 45 minutes to complete the questionnaire.

4.4 Results from Research Question Two

This part of the study presents the results for research question two following the individual sections of the survey questionnaire.

4.4.1 Demographics

This exploratory study had a total sample size of five polled professionals. All five of them were male, and three of them identified themselves as designers of business intelligence information systems, while the remaining two declared to be users of BI information systems.

Figure 3 illustrates the distribution of age groups in the survey sample. 60% of the respondents were between 35 and 44 years of age, while 20% fell into the group of 25 – 34, and another 20 % into the group of 45 – 54 years of age.

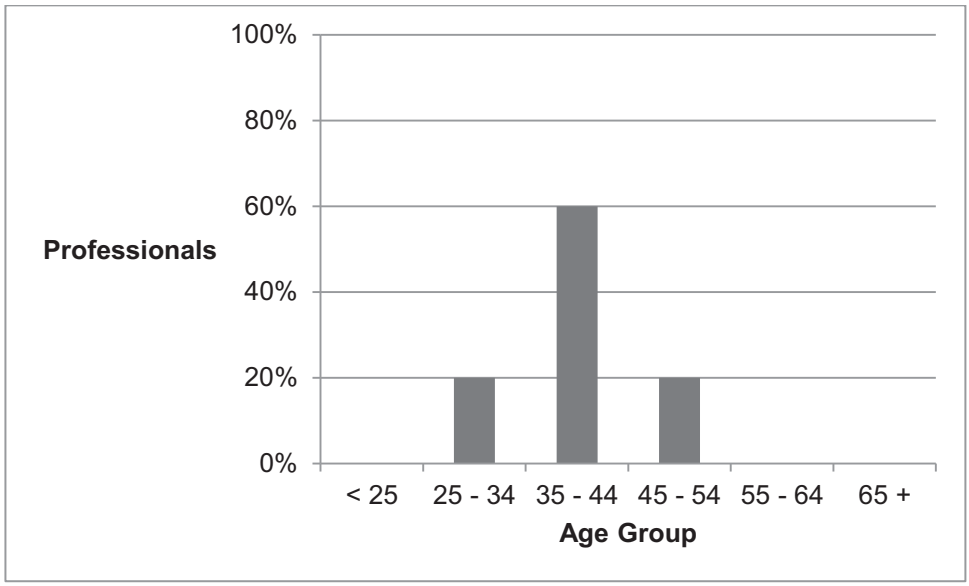

Figure 3. Age Group Distribution.

Figure 4 shows the distribution of working experience with business intelligence information systems among the respondents, measured in years. While 60 % of the interviewed professionals had 5 – 9 years of experience, there were 20 % of the respondents in each of the two groups of 2 – 4 years and 15 – 19 years.

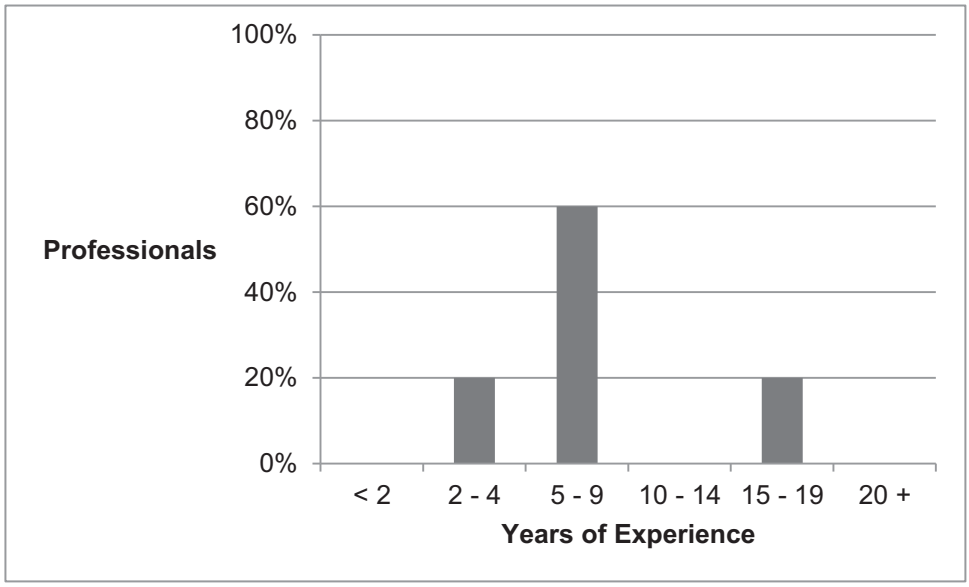

Figure 4. Distribution of Experience with BI Information Systems.

Figure 5 presents the distribution of responses regarding the typical organization size measured in number of employees, where the survey respondents implement or use

business intelligence information systems. 80 % were working with BI information systems in very large organizations with over 10,000 employees, and the remaining 20 % had experience with BI from organizations with a size between 150 and 250 employees, which are categorized as 'medium-sized enterprises' according to European Commission recommendation (European Commission, 2003).

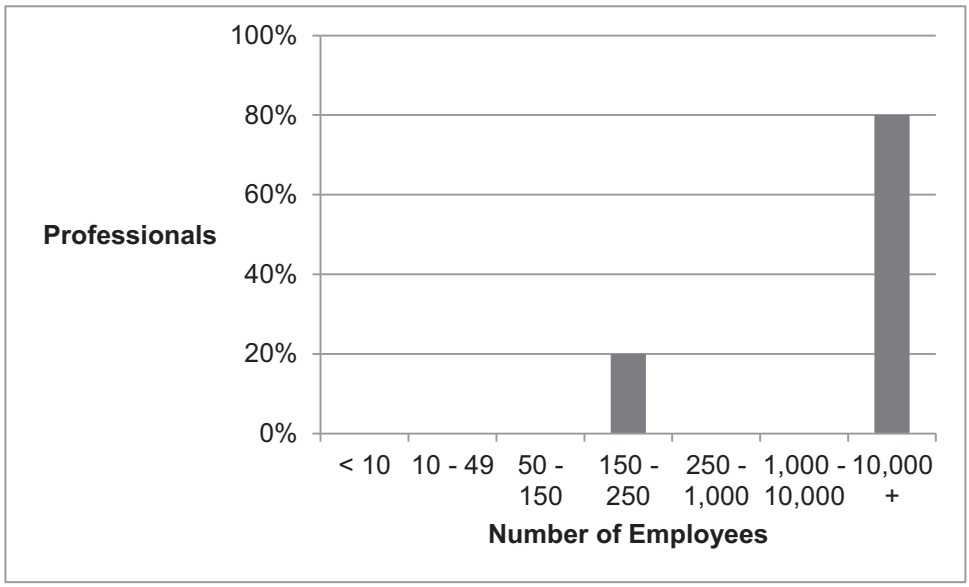

Figure 5. Distribution of Typical Organization Size for implementing BI Information Systems.

4.4.2 Hypothesis 1

The measures associated with hypothesis 1 were placed in section two of the survey questionnaire. These measures were designed to test for the opposite of consequences and behavior induced from hypothesis 1. The respondents were requested to indicate their agreement or disagreement towards statements that suggested no benefit to organizations from the introduction of closed-loop management control.

Table 5 lists the detailed results for means and standard deviations on measures of approval towards closed-loop management control system capabilities.

Table 5. Means and Standard Deviations on Measures of Approval towards Closed-loop Management Control.

Scale	Strongly disagree = 1, Strongly agree = 5		
Item No.	**Description**	**Mean**	**Std Dev**
2.1	No Benefit from Working based on Factual Decisions and Defined Processes	1.4	0.55
2.2	No Efficiency Increase through Linking Decision-making to Work Activities	1.6	0.55
2.3	Execution of Management Tasks unaffected by Closed-loop Management Control	3.0	1.00
2.4	Advice against Closed-loop Management Control	1.0	0.00

The results showed that respondents uniformly disagreed or strongly disagreed to items 2.1, 2.2, and 2.4, which indicates a positive attitude of the respondents towards the capabilities of closed-loop management control. With item 2.3, suggesting that management difficulties would not be improved by closed-loop management control, the results were more scattered. While responses were fluctuating between agreement and disagreement the mean value lead to a neutral result for this item. Overall, the test for the opposite of hypothesis 1 returned false. Therefore, hypothesis 1 is assumed to be true until falsified by future research.

Respondents were also requested to provide explanations for their responses. For item 2.1 the majority of professionals emphasized the importance of factual data as a basis for informed decisions. From their working experience, proper management control is not possible without fact-based objectives, as most decision-making tends to be random and subjective without factual data. But, as one respondent pointed out, the actual benefit from factual decisions and defined processes depends on the size, structure, and objectives of an organization.

For item 2.2 explanations were given that linking decision-making to work activities helps minimizing human error and helps avoiding limited overview of actual work activities. One respondent indicated that, although new to the services domain, the

concept of linking decision-making to work activities has already been an accepted standard for decades in manufacturing.

The responses for item 2.3 had the most variation in their results. Respondents disagreeing with the statement explained that there is not enough process control with existing management structures. Using closed-loop management control, decisions would be more in line with preset objectives. Respondents agreeing with the statement described that difficulties from executing management tasks are largely driven by organizational politics and thus would not be sufficiently improved by using closed-loop management control.

Regarding item 2.4 all of the respondents would advise for the introduction of a closed-loop management control system for their organizations. They would embrace a system that would help identifying incorrect decisions and would elevate management to an increased level of professionalism.

4.4.3 Extending Capabilities of BI Information Systems

Section three of the survey was not attached to one of the hypotheses, but rather tested the attractiveness of advanced capabilities that closed-loop management control systems would provide in extension of contemporary business intelligence information systems. The respondents were requested to indicate the perceived attractiveness of extended capabilities that correspond to the advanced levels of the controller category and both levels of the actuator category of the CMCS characteristics comparison tool introduced in section 3.2.

Table 6 lists the detailed results for means and standard deviations on measures of attractiveness of extending BI capabilities.

The respondents agreed on the highest scores for attractiveness for items 3.1 and 3.4, together with the lowest deviation in section three. Item 3.2 was next in the order of attractiveness with an average rating well above ‘attractive’, but it also had the highest variability in the distribution of responses, fluctuating at more than one full grade. Items 3.3 and 3.5 both received attractiveness ratings above a neutral mean value, but the responses also fluctuated by almost one full grade. In general, respondents found the extended capabilities provided by closed-loop management

control all to be attractive, but there was a significant level of disagreement by one full grade about three of the five section items.

Table 6. Means and Standard Deviations on Measures of Attractiveness of Extending BI Capabilities.

Scale	Not attractive = 1, Extremely attractive = 5		
Item No.	**Description**	**Mean**	**Std Dev**
3.1	Predictive Decision Support	4.6	0.55
3.2	Computing Optimized Corrective Action	4.2	1.10
3.3	Decision-making Automation	3.4	0.89
3.4	Operating System Change Effecting	4.4	0.55
3.5	Process Flow Automation	3.8	0.84

Explanations for the responses to item 3.1 quoted the importance of statistical prediction of future business development for every organization. Despite that, several respondents stressed the necessity to properly design the forecasting process in order to avoid wrong predictions.

For item 3.2 some explanations indicated at past experience in manufacturing where optimization is a fundamental key functionality of production planning. While some respondents appreciated the application of optimization to service organizations, others saw limited use of this approach beyond industrial manufacturing environments.

Several of the respondents saw a benefit in the automation of (less important) decisions in order to free up capacities of decision makers for important activities. Other explanations provided to the answers to item 3.3 were less affirmative and

stated that, because of low data quality and similar issues, decision-making should always be a task of people.

With item 3.4, all respondents agreed on the positive attractiveness of workflow execution, associating it with benefits such as being less prone to error and enabling cost savings through increased efficiency.

Concerning item 3.5 the respondents explained that process flow automation is a positive feature that helps to reduce waste and also frees up staff resources that can be utilized for other tasks. Yet, they are aware that automation works best for processes that are dominated by technical systems and is less applicable to processes with a high level of human interaction.

4.4.4 Hypothesis 2

Section four of the survey questionnaire consisted of questions related to hypothesis 2. These questions were designed to test for the opposite of the induced consequences and behavior from hypothesis 2. The respondents were asked to grade their agreement or disagreement with statements regarding their satisfaction with information received or acquired about systems control principles for use with BI management support information systems.

Table 7 lists the detailed results for means and standard deviations on measures of satisfaction with information received or acquired about systems control principles in BI management support.

The results illustrate that the respondents generally disagree with the items 4.1 and 4.2 which together indicate that professionals are not satisfied with the information they receive about systems control principles from vendors or are able to acquire on their own from industry analysts. Calculating standard deviation discloses a notable fluctuation in the distribution of the responses, but the results remain well above the neutral value. Taking the average of responses for item 4.3 results in a neutral value. The attached significant fluctuation of one full grade indicates that there were fewer consistencies in the responses for this item. For every professional disagreeing with the statement that vendor usage scenarios were considered when designing new BI systems, another one agreed with the statement. Overall, the test for the opposite of

hypothesis 2 returned false, although the result is less precise than the test for hypothesis 1. For the purpose of this qualitative study, hypothesis 2 is assumed to be true until falsified by future research.

Table 7. Means and Standard Deviations on Measures of Satisfaction with Information about Systems Control Principles.

Scale	Strongly disagree = 1, Strongly agree = 5		
Item No.	**Description**	**Mean**	**Std Dev**
4.1	Being Informed about Systems Control Principles for BI	2.0	0.71
4.2	Satisfied with Time allocated to Review BI Analyst Reports	1.8	0.84
4.3	Published Usage Scenarios considered when creating New BI Systems	3.0	1.00

The respondents explained that overall, they did not feel informed by vendors about systems control principles in connection with BI management support systems as covered in item 4.1. In most cases the topic has not been addressed at all. Based on one experience, in some cases information is available on the individual parts of a closed-loop management control system, but is not being evaluated in the context of such a comprehensive system.

For item 4.2 the majority of respondents described that they were not able to allocate enough time to review analyst reports due to ongoing operational work and error fixing. They expressed their intention to dedicate more time to acquiring knowledge in the future. For one respondent the available time was depending on the current workload and changed regularly.

The reported experience with item 4.3 describes that for half of the respondent's organizations, reference cases and usage scenarios are very important and seem to have high influence on new projects. The other half experienced that references were only rarely considered for designing new systems, where one respondent reported that his organization at least tried to be open and pragmatic to new approaches.

4.4.5 Hypothesis 3

The measures associated with hypothesis 3 were placed in section five of the survey questionnaire. These measures were designed to test for the opposite of consequences and behavior induced from hypothesis 3. The respondents were requested to indicate their agreement or disagreement towards statements that suggested that organizations responsible for the introduction of BI information systems were process-oriented, used a top-down systems implementation approach, and supported the convergence of BI and BPM systems.

Table 8 lists the detailed results for means and standard deviations on measures of factors influencing the adoption of systems control principles for BI systems.

Table 8. Means and Standard Deviations on Measures of Factors influencing the Adoption of Systems Control Principles for BI Systems.

Scale	Strongly disagree = 1, Strongly agree = 5		
Item No.	**Description**	**Mean**	**Std Dev**
5.1	Organization responsible for BI Systems is Process-oriented	2.6	0.89
5.2	Development of BI Systems follows Top-down Approach	2.8	1.30
5.3	Organization supports Convergence of BI and BPM	1.8	1.30

The results for items 5.1 and 5.2 returned an almost neutral average value with a light tendency towards disagreement. The ambiguity of the results is amplified by the fluctuation of individual responses represented by the elevated values for standard deviation. With item 5.3 the result is clearly defined towards disagreement, but still suffers from fluctuation in the responses of over one full grade. For the purpose of this qualitative study, the test for the opposite of hypothesis 3 is set to false due to the mean result values not passing over the neutral threshold value. Hypothesis 3 is assumed to be true until falsified by future research.

Over half of the respondents explained their responses for item 5.1 with experiencing organization structures that had a very vertical-departmental nature and were often driven by inter-departmental struggles for power. The remaining professionals had either a mixed organizational structure at their workplace or were supported by process-oriented organizations.

For item 5.2 the majority of respondents described organizations where using a top-down systems approach is not fully understood, overall systems architecture seems to be missing, and individual teams were implementing multiple comparable systems without sharing information. Positive experiences with using top-down systems approach were made with manufacturing organizations.

The majority of respondents also did not yet encounter any attempts of convergence of BI and BPM systems as investigated with item 5.3. Where there was any inter-departmental cooperation towards this convergence objective, it was described as being spontaneous and unplanned. Only a limited number of respondents experienced attempts to create an integrated system of BI and BPM subsystems.

4.5 Discussion of Findings from Research Question Two

After presenting detailed results from the research conducted in association with research question two, this subsequent section discusses the findings induced from the survey results.

From section 4.4.2 it was evident that there was a strong belief among users and designers of BI information systems that fact-based decisions and defined processes are beneficiary to corporations and other organizations. Furthermore, professionals expected increased efficiency when decision-making is linked to the resulting work activities. All these functionalities are characteristics of closed-loop management control, thus supporting the hypothesis that BI users and designers find such system to be attractive for use in managing organizations. This result was further confirmed by the uniform endorsement to promote the introduction of closed-loop management control systems at their organizations. The results were more ambiguous when professionals expressed their opinion if closed-loop management control systems would improve difficulties experienced in the execution of management tasks. The

survey showed that a significant portion of these tasks seems to be dependent on managerial soft skills and organizational politics, and thus would not be improved by information system support. This specific result was somewhat contradictory to the previously expressed approval of system control principles. Future research such investigate this matter in more detail and narrow down survey questions to specific task execution problems and the effect of disconnection between decisions and resulting work activities.

Research in section 4.4.3 showed that extended capabilities of closed-loop management control systems that received the highest attractiveness ratings were predictive decision support and optimization. As both functionalities are already available through advanced business intelligence products, it can be assumed that the observed popularity was due to their recognized position on the market. References to manufacturing made in the response explanations confirmed that optimization and other well-established methods from production control are being increasingly accepted in other domains as well, such as services. This development has also been discussed in section 2.3. The survey also returned results that indicated a high attractiveness of supporting work execution activities with information systems such as workflow and BPM systems. Given that business process management systems have only recently started to enter the early mainstream phase, as quoted in section 2.6, lower levels of approval would have been expected here. The acceptance level towards this category of systems is another indicator for the readiness of the BI market to embrace advanced levels of information systems following system control principles. Research investigating the concept of automation in BI has also returned approval to this concept, but with significantly lower ratings then other capabilities. This indicates that professionals are well aware that automating process flows is reasonable only for technical processes, which are common to production environments, but less so in the services domain. Users and designers of BI systems also recognized the benefit of automating simple, less important decisions. Yet, in general they remained cautious towards machine-based decisions and favored to leave decision-making to humans.

From the results of section 4.4.4 it was evident that users and designers of BI information systems do not have sufficient information on system control principles

applied to organizational management. Without adequate information from BI product vendors, and not being able to allocate enough time to acquire information from additional sources, such as analyst reports, it is not surprising that there are only few reports of successfully implemented closed-loop management control systems as observed in chapter 3. Research in section 4.4.4 has also revealed that more attention is being paid to reference cases and usage scenarios published by BI product vendors, but examinations in chapter 3 demonstrated that this material mainly contains cases of less-complex, reporting-oriented BI systems. As such, the available material is not significantly contributing to spreading information about system control principles.

Research in section 4.4.5 revealed that users and designers of BI information systems have not significantly experienced attempts of converging BI and BPM systems in their respective organizations. The provided successful cases of such convergence originated from the manufacturing domain, where comparable systems are common. Section 4.4.5 also returned ambiguous results for the assumed correlation of limited adoption rate of closed-loop management control systems with organizations lacking process-orientation and utilization of the top-down systems approach. Although the average response value is still in a range where hypothesis 3 has not been rejected, product-centric vertical organization structures and the use of bottom-up approaches to implement BI do not seem to correlate with the lack of adoption of closed-loop management control systems as strongly as expected. Further research should attempt to investigate other possible causes for this phenomenon.

4.6 Summary of Research Question Two

This chapter presented the research efforts conducted for investigating and answering research question two. Following a short introduction, RQ2 has been examined for more detailed definitions of the research question, and the resulting characterizations have been stated in the form of three hypotheses. The next part of the chapter introduced the research method that was applied for answering the hypotheses. It described individual sections of a questionnaire that was used as a research instrument in a qualitative survey targeted at users and designers of business intelligence systems, and how these sections related to the research associated with the previously established hypotheses.

The consecutive part of the chapter presented the results from evaluating the survey responses. For each section of the questionnaire, mean values and standard deviation for every section item was presented in a tabular form. Additionally, the sections also contained statements given by the study respondents to explain their individual answers. From the survey results it was evident that extended capabilities of comprehensive management control systems were attractive for users and designers of BI information systems. The subsequent discussion of findings stated that there is an obvious lack of sufficient information about system control principles among professionals in business intelligence. Lack of process-orientation, and neglecting a top-down systems approach when implementing BI information systems in organizations, could not have been clearly correlated as a cause for the limited adoption of closed-loop management control systems.

The following chapter concludes this study by summarizing research findings and answers to the stated research questions. It also indicates research limitations and suggests recommendations for future research.

5 CONCLUSIONS

This chapter summarizes the research results acquired throughout this study, and indicates research limitations and suggests recommendations for future research.

5.1 Introduction

For being able to properly evaluate the outcome of the study at hand, it is important to briefly revisit the initial research objective and the resulting research questions and to compare them against the findings from research. This close comparison will provide an unbiased view on the achieved results, indicating achieved results and identifying questions that were not properly answered yet, thus suggesting potential topics for further research.

5.2 Reflection of Research Objective

Section 1.3 defined the research objective of this study on the basis of a list of questions that described the field of interest of the upcoming examination of system control and business intelligence information systems. Proper consideration of these questions within the study should result in interesting insight and ensure that the results would be relevant for the attempt to gain more knowledge about the state of closed-loop management control systems.

A fundamental part of the research objective was the investigation of capabilities of available business intelligence software products and their qualification for implementing closed-loop management control systems. This has been successfully achieved by creating a comparison instrument against a conceptual management control system and answering research question one in chapter 3.

Based on these results, another part of the research objective has been covered within chapter 3 by extending the examination of BI products to include higher-level hierarchical systems that could also be used to implement closed-loop management control and not be limited by built-in capabilities of available BI products. This category of systems has been carefully considered in the design of the comparison instrument.

One interesting aspect in the exploration of closed-loop management control was to gain better understanding about the level of knowledge that users and designers of BI systems have about the principles of systems control and their application to support the management of organizations. This information is most relevant for assessing the future development of this field of interest. This question has been addressed in the research for chapter 4 by dedicating a full section of the survey instrument to this problem.

Investigating the attitude of users and designers of BI information systems towards closed-loop management control and their advanced capabilities has been a central aspect of this study. This contribution to the research objective was accounted for in two sections of the survey instrument. In the first step, the appeal of general system control principles to professionals has been measured, whereas in the second step, the attractiveness of individual advanced capabilities was examined.

Being suspected factors for correlating with the limited deployment of closed-loop management control systems encountered the examination of departmental structures and architecture approaches in implementation was also one part of the research objective. This question has also been addressed by providing a dedicated section in the survey questionnaire.

As all of the outlined fields of interest have been addressed in the study, it can be stated that the research objective has been achieved.

5.3 Research Results Summary

The definition of the research objective led to the formulation of two specific research questions. Through the research carried out in this study it was possible to successfully answer both of them.

RQ1: Do business intelligence information systems deliver, or are being integrated into, a comprehensive management control system for organizations?

From the research conducted in chapter 2 it was evident that available standalone business intelligence products have insufficient features for delivering a comprehensive management control system. These software products all offer strong

sensor capabilities for measuring operating system feedback, and also provide basic to advanced levels of decision support functionality for controller activities. However, there is no significant evidence that the available capabilities are used to create a substantial amount of closed-loop system implementations using a hierarchy of heterogeneous systems, which require the adoption of actuator activities through workflows and BPM systems, and would also be expected to show examples of optimizing corrective actions and at least partial automation of decisions and process flows.

RQ2: Would the extended capabilities of comprehensive management control systems be attractive for users and designers of business intelligence information systems?

From the survey results presented in chapter 3 it was evident that extended capabilities of comprehensive management control systems were attractive for users and designers of BI information systems. Additional detailed findings stated that there is an obvious lack of sufficient information about system control principles among professionals in business intelligence. Lack of process-orientation, and neglecting a top-down systems approach when implementing BI information systems in organizations, could not have been clearly correlated as a cause for the limited adoption of closed-loop management control systems.

In extension of the answers provided to the research questions a number of implications can be drawn from the discoveries of this study. While it has been demonstrated that standalone business intelligence products have insufficient features for delivering a comprehensive management control system, this should not inhibit the creation of such systems from the technical point of view. Available BI products have adequate capabilities to fully support the required sensing and computation steps of the feedback loop, and missing functionality focused in the actuation step can be substituted by creating hierarchical systems together with other software components such as BPM systems. It was noticeable in the analysis of results that while the concept of closed-loop management control was appealing to users and designers of BI systems, there is very limited knowledge about such systems and the underlying system control principles among this group. This is evidently a major

cause of the low adoption rate of closed-loop management control systems in today's organizations. Product vendors and industry analysts need to find improved ways of communicating the benefits and capabilities of closed-loop management control in order to propagate this reasonable concept in the market.

5.4 Research Limitations

The research results presented in this study must be observed considering a series of limitations that have influenced the outcome.

Due to time constraints, only a limited number of users and designers of BI systems had been accessed for the survey. While the results still provided interesting qualitative insight, they are not statistically significant caused by the small sample size. Additionally, the selection of survey respondents was geographically constrained to only a small area around the place of origin of the study. As a consequence of this limitation, the results cannot be interpreted as being valid beyond this specific market sector.

Time constraints have also limited the number of BI products and vendors examined for the assessment of product capabilities. While products were sampled from a world-wide list of leading vendors and represented a global selection, capabilities of other BI products that might be of importance to closed-loop management control remained undiscovered.

5.5 Recommendations for further Research

Further research should attempt to compensate the limitations of this study in order to improve the relevance of results. The most important measure would be to increase the sample size of product comparison and survey in order to deliver statistically significant results. As to the questionnaire instrument used for RQ2, the sample should include respondents from multiple geographic areas and market segments.

The examination of survey results revealed that some items may have caused responses that contradicted other responses by the same individual. These items

should be reworked and changed to more detailed questions in order to better express the intent of the items.

Lack of process-orientation in organizations and related factors could not have been clearly identified as a cause for the limited adoption of closed-loop management control systems. Further research should attempt to investigate other possible causes for this phenomenon, and repeat the examination of the above factors in a more detailed research in order to improve the present ambiguous results.

5.6 Summary of Conclusions

The final chapter of this study provided a summary of the research that has been conducted in this study.

A reflection of the initial research objective has shown that all relevant questions formulated at the beginning of the research process have been successfully addressed. The next section provided answers for the two research questions and also delivered a number of implications were drawn from the discoveries of this study.

The chapter has been concluded with discussing research limitations and suggesting recommendations for future research.

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APPENDICES

Appendix A – CMCS Characteristics Comparison Table

Table 1 CMCS Characteristics Comparison

Conceptual Management Control System Characteristics	BI Product Characteristics	Reference Implementation Characteristics
Level of Management		
Strategic	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Tactical	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Operational	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Sensor		
Operating System Feedback Measurement	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Controller		
Fact-based Decision Support	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
As-Is/To-Be Comparison	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Predictive Decision Support	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Computing Optimized Corrective Action	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Decision-Making Automation	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Actuator		
Operating System Change Effecting	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*
Process Flow Automation	*[Strong | Medium | Weak | None]*	*[Strong | Medium | Weak | None]*

Appendix B – RQ2 Research Instrument

INTRODUCTION

- There are five sections in this survey. Please take some time to complete all five of them.
- Please read the statements and questions carefully before giving your answer.
- You are asked if you agree/disagree with a statement or like/dislike a certain item. Please circle the number along the numeric scale that best describes your answer.
- Please try to explain your answers using keywords in the designated area below each statement or question. You can also use examples to explain your answers.
- All responses will be treated with the utmost confidentiality.
- The general findings of this questionnaire will be used in academic research and may be disclosed to corporations, government organizations, or at industry and research conferences in order to help understand the particular situation.

1 PROFESSIONAL BACKGROUND

1.1 What age are you?

< 25 **25 – 34** **35 – 44** **45 – 54** **55 – 64** **65 +**

1.2 Are you female or male?

Female **Male**

1.3 Are you a user or designer of business intelligence information systems?

User **Designer**

1.4 How many years of experience do you have working with business intelligence information systems?

< 2 **2 – 4** **5 – 9** **10 – 14** **15 – 19** **20 +**

1.5 What is the size of your organization, in number of employees?

< 10 **10 – 49** **50 – 150** **150 – 250**

250 – 1000 **1000 – 10000** **10000 +**

1.6 What is the typical size of organizations where you work with business intelligence information systems, in number of employees?

< 10 **10 – 49** **50 – 150** **150 – 250**

250 – 1000 **1000 – 10000** **10000 +**

2 ATTITUDE TOWARDS CLOSED-LOOP MANAGEMENT SUPPORT CAPABILITIES

2.1 I think that corporations do **not** significantly benefit from conducting work based on factual decisions and defined processes.

Strongly				**Neither agree nor disagree**				**Strongly**
disagree	**1**	- - - - - - -	**2**	- - - - - - -	**3**	- - - - - - -	**4**	- - - - - - -	**5**	**agree**

Please explain (Describe examples where possible).

_____

_____

_____

_____

2.2 I think that linking of decision-making to the resulting work action through information technology does **not** significantly increase efficiency.

				Neither agree					
Strongly				**nor disagree**					**Strongly**
disagree	**1**	**- - - - - - -**	**2**	**- - - - - - -**	**3**	**- - - - - - -**	**4**	**- - - - - - -**	**5** **agree**

Please explain (Describe examples where possible).

_____

_____

_____

_____

2.3 I think that in my organization, difficulties in executing management tasks are/would be unaffected by using a closed-loop management support system.

				Neither agree					
Strongly				**nor disagree**					**Strongly**
disagree	**1**	**- - - - - - -**	**2**	**- - - - - - -**	**3**	**- - - - - - -**	**4**	**- - - - - - -**	**5** **agree**

Please explain (Describe examples where possible).

_____

_____

_____

_____

2.4 I have advised/would advise against the implementation of a closed-loop management support system in my organization.

Strongly				**Neither agree nor disagree**				**Strongly**
disagree	**1**	**- - - - - - -**	**2**	**- - - - - - -**	**3**	**- - - - - - -**	**4**	**- - - - - - -**	**5**	**agree**

Please explain (Describe examples where possible).

_____

_____

_____

_____

3 ATTITUDE TOWARDS EXTENDING CAPABILITIES OF CONTEMPORARY BI INFORMATION SYSTEMS

3.1 Is predictive decision support (e.g. forecasting) as an extended capability of closed-loop management support systems attractive for you?

Neither attractive

Not nor unattractive Extremely

attractive 1 - - - - - - - 2 - - - - - - - 3 - - - - - - - 4 - - - - - - - 5 attractive

Please explain (Describe examples where possible).

3.2 Is computed optimization in decision-making as an extended capability of closed-loop management support systems attractive for you?

Neither attractive

Not nor unattractive Extremely

attractive 1 - - - - - - - 2 - - - - - - - 3 - - - - - - - 4 - - - - - - - 5 attractive

Please explain (Describe examples where possible).

3.3 Is automation of decision-making as an extended capability of closed-loop management support systems attractive for you?

Neither attractive

Not **nor unattractive** **Extremely**

attractive 1 - - - - - - - 2 - - - - - - - 3 - - - - - - - 4 - - - - - - - 5 attractive

Please explain (Describe examples where possible).

3.4 Is information system-assisted execution of work activities as an extended capability of closed-loop management support systems attractive for you?

Neither attractive

Not **nor unattractive** **Extremely**

attractive 1 - - - - - - - 2 - - - - - - - 3 - - - - - - - 4 - - - - - - - 5 attractive

Please explain (Describe examples where possible).

3.5 Is process flow automation as an extended capability of closed-loop management support systems attractive for you?

				Neither attractive					
Not				**nor unattractive**					**Extremely**
attractive	**1**	**- - - - - - -**	**2**	**- - - - - - -**	**3**	**- - - - - - -**	**4**	**- - - - - - -**	**5** **attractive**

Please explain (Describe examples where possible).

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4 SATISFACTION WITH INFORMATION RECEIVED OR ACQUIRED ON SYSTEMS CONTROL PRINCIPLES IN BI MANAGEMENT SUPPORT

4.1 I feel sufficiently informed by BI systems vendors/consultants or BI product management about the application of systems control principles in BI management support.

				Neither agree					
Strongly				**nor disagree**					**Strongly**
disagree	**1**	**- - - - - - -**	**2**	**- - - - - - -**	**3**	**- - - - - - -**	**4**	**- - - - - - -**	**5** **agree**

Please explain (Describe examples where possible).

4.2 I am satisfied with the amount of time that I can allocate at my workplace to review industry analyst trend reports in the area of BI management support.

				Neither agree					
Strongly				**nor disagree**					**Strongly**
disagree	**1**	**-**	**-**	**2**	**-**	**-**	**3**	**-**	**4**	**-**	**-**	**5**	**agree**

Please explain (Describe examples where possible).

4.3 When specifying or designing a new BI management support system, I think that my organization also takes into account the usage scenarios being published through internal/external product information material from the BI system vendor.

				Neither agree					
Strongly				**nor disagree**					**Strongly**
disagree	**1**	**-**	**-**	**2**	**-**	**-**	**3**	**-**	**4**	**-**	**-**	**5**	**agree**

Please explain (Describe examples where possible).

5 FACTORS INFLUENCING THE ADOPTION OF BI MANAGEMENT SUPPORT SYSTEMS BASED ON SYSTEMS CONTROL PRINCIPLES.

5.1 I think that the subdomain of my organization responsible for specifying or developing BI management support systems has a more process-oriented and less vertical-departmental structure.

				Neither agree				
Strongly				**nor disagree**				**Strongly**
disagree	**1**	**- - - - - - -**	**2**	**- - - - - - -**	**3**	**- - - - - - -**	**4**	**- - - - - - - 5** **agree**

Please explain (Describe examples where possible).

5.2 I think that the majority of BI management support systems specified or developed at my organization follow a top-down systems approach.

				Neither agree				
Strongly				**nor disagree**				**Strongly**
disagree	**1**	**- - - - - - -**	**2**	**- - - - - - -**	**3**	**- - - - - - -**	**4**	**- - - - - - - 5** **agree**

Please explain (Describe examples where possible).

5.3 I think that my organization sufficiently supports inter-departmental cooperation towards the convergence of business intelligence and business process management.

				Neither agree					
Strongly				**nor disagree**					**Strongly**
disagree	**1**	- - - - - - -	**2**	- - - - - - -	**3**	- - - - - - -	**4**	- - - - - - -	**5** **agree**

Please explain (Describe examples where possible).