

Using Data Mining Techniques for Information System Research Purposes – An Exemplary Application in the Field of Business Intelligence and Corporate Performance Management Research

Karin Hartl, Olaf Jacob

Department of Information Management
University of Applied Sciences Neu-Ulm
Neu-Ulm, Germany
karin.hartl@hs-neu-ulm.de, olaf.jacob@hs-neu-ulm.de

Abstract—Corporate Performance Management (CPM) is a management concept based on performance measures. These measures are supplied by Business Intelligence (BI), which transformed information technology in companies from data storage solutions towards decision support systems. It is believed that BI enhances CPM and that BI needs CPM for a purposeful commitment. To gain a detailed insight in the relationship between these two constructs a Data Mining approach is used. Data Mining is a data driven statistical approach for knowledge discovery. In comparison to commonly used Information System research approaches, like Structural Equation Modelling, in Data Mining no hypothesis have to be developed beforehand. Therefore, otherwise undiscovered patterns, information and hypothesis embedded in a given dataset can be discovered. As an example, Association Rule Discovery has been applied to a questionnaire based dataset investigating the relationship between BI and CPM. The results of the Data Mining approach show indeed more detailed information about the connection of BI and CPM than the usually applied research methods Exploratory Factor Analysis and Structural Equation Modelling.

Keywords-Data Mining; Association Rule Discovery; Business Intelligence; Corporate Performance Management.

I. INTRODUCTION

This research aims to explore the connection between Business Intelligence (BI) and Corporate Performance Management (CPM) to make the business value of BI tangible. The approach used is Data Mining. Data Mining are data-driven and hypothesis free methods, identifying patterns, information and hypothesis embedded in a given dataset [23][16]. In Information System (IS) research – especially regarding the connection between BI and CPM – Explanatory Factor Analysis (EFA) and Structural Equation Modelling (SEM) are the commonly used approaches. Before applying the statistical analysis, research assumptions and hypothesis have to be developed and later confirmed with data collected for this specific research purpose. This approach has one major limitation, its reliance on human imagination for generating research assumptions [20]. Instead, Data Mining techniques are working up from the data [23]. Hypothesis are not necessarily developed beforehand, making the detection of new and unexpected connections in the dataset possible. It

is believed, that more detailed knowledge can be discovered by using exploratory Data Mining techniques.

Association Rule Discovery is a widely used and well-known Data Mining method and therefore has been identified as a suitable first approach in exploring the value Data Mining has for IS research. Association Rule Discovery searches for structural connections in a dataset, formulate If-Then-Statements and can take all available research criteria into account. In this research example, the results of the Association Rule Analysis could allow conclusions on the BI capabilities supporting successful CPM. As both CPM and BI consist of several characteristics, the Data Mining approach could help to focus on the important features in each area too.

In Section 2, a short introduction on the importance of the thematic research background is given, pointing out why an investigation of the connection between BI and CPM is necessary. Section 3 discusses the subject related research and the empirical approaches used in these studies. In Section 4, the motivators for using the non-traditional IS research approach Data Mining are evaluated. In Section 5, the research approach to the exemplary subject is described, and, in Section 6 the results for this example are presented. Section 7 discusses the sample results and the conclusion in Section 8 summarizes the benefits of using the Data Mining approach.

II. THEORY AND RESEARCH BACKGROUND

The challenge companies have to face nowadays for success and existence proves to be increasingly difficult. Globalization intensifies the competition and digitalization leaves enterprises with an immense amount of mainly unstructured data. These data and the contained information, however, are assumed to be the key to ensure the survival of an enterprise in the rapidly changing business environment. BI as a method of analysing data and the business environment promises companies to support their decision making process [1][23]. The support is achieved by acquiring, analysing and disseminating information from data significant to the business activities [7]. Accordingly, BI is seen as a source for quality data and actionable information. This implies that the appropriate use of BI systems supports the success of organizations [10].

As BI projects are not exempt from the increasing pressure in companies to justify the return on IT investment, the business value of BI needs to be measured [18]. Due to the

abstract nature of BI, capturing its value is a strategic challenge [14][28]. Generally, BI systems do not pay for themselves strictly by cost reduction. Most BI benefits are intangible and hard to measure [18]. Williams and Williams [28] point out that the business value of BI lies in its use within the management processes. Therefore, the concept of CPM evolved, which is understood as the appropriate context to prove the value proposition and benefits of BI [14][15]. It is defined by Gartner as “an umbrella term that describes all processes, methodologies, metrics and systems needed to measure and manage the performance of an organization” [3]. CPM presents the strategic deployment of BI solutions and is born out of a company need to proactively manage business performance [4][13]. Inferentially, CPM needs BI to work effectively on accurate, timely and high quality data and BI needs CPM for a purposeful commitment [3]. As a consequence, it is expected that the effectiveness of CPM increases with the effectiveness of the BI solution and therefore company success improves as well [22].

III. SUBJECT RELATED RESEARCH

In the last couple of years, various studies regarding the relationship between BI and performance management emerged.

Miranda [15] brought BI into context with CPM by summarizing CPM as a business management approach that supports companies in their way of operation by using business analysis. CPM is identified as a suitable framework for determining the business value of BI. Although no observable empirical background and foundation is provided, this article supplies the foundation for more detailed research in the field, including the following.

Empirical studies on the investigation of the connection between BI and CPM have mainly been realized just recently. Aho [1] evaluates the differences and similarities between BI and CPM by conducting a literature study and action oriented research. The results indicate that BI and CPM need to work together to be efficient and effective. However, the rather weak empirical background does not deliver any details on the relationship of BI and CPM.

Yogev et al. [29] address the question of the business value gained by implementing a BI system in an enterprise by using a process oriented approach. The research model identifies key BI resources and capabilities as possible explanatory factors of the value creation that can be accomplished with the implementation and application of a BI system. Hypothesis are formulated and tested using Explanatory Factor Analysis (EFA) and Structural Equation Modelling (SEM). The results illustrate that BI has a positive effect on both the operational and the strategic level of the company. Nevertheless, the empiricism does not provide any details about the BI related resources creating this positive effect.

Saed [24] investigates the relationship between BI and business success using regression and correlation analysis. While these statistical techniques provide room for detailed results, only aggregated explanations have been provided.

Richards et al. [22] are the first to directly investigate the impact and connection of BI on CPM using EFA and SEM. The research model supposes that BI directly influences and

supports measurement, planning and analytics. The effectiveness of planning, measurement and analytics, again, influences the effectiveness of the company processes. Through a large-scale survey, sample data has been collected. Afterwards, with EFA the number of variables comprised in the questionnaire has been reduced followed by the Partial Least Square (PLS) analysis. Even though the research identifies a direction of how BI influences CPM, the specific BI mechanisms that do so are not defined.

This research project complements the subject related work, as the previous findings have been used as the initial point. But besides discovering and proving a positive connection between BI and CPM, these researches lack detail. Instead of grouping the characteristics and measurement items describing BI and CPM with EFA and SEM together, all items are considered separately. It is believed that this approach helps to get an in-depth insight into the relationship between BI and CPM.

IV. MOTIVATION FOR THE DATA MINING APPROACH

The common approach in the research field of determining the value of BI is using EFA first and then CFA second. With the EFA correlating items are organized together in groups and summed up as a factor [2]. Data can be structured and reduced this way. This structured and reduced data are then analysed with the PLS method by seeking the optimal predictive linear relationship to assess the previously defined causal relationship [26][27]. The creation of factors for compacting information might be the right approach for many research subjects, but it must not be the only correct approach to explore connections in IS research. It is assumed that Data Mining can highly contribute to the subject. Data Mining is a data driven approach and supports the discovery of new and sometimes unexpected knowledge [20]. Instead of only testing assumed hypothesis, with Data Mining otherwise undiscovered data attributes, trends and patterns can be explored [6]. Especially with explanatory Data Mining techniques, a better understanding of connections in the dataset can be achieved [5]. Although Data Mining is often only seen as most suitable for large datasets, Natek and Zwilling [17] disclose that the use of small datasets in general are not limiting the use of the tool. Data Mining can be understood as an extension of statistical data analysis and statistical approaches [9]. Both approaches aim to discover structure in data, but Data Mining methods are generally robust to non-linear data, complex relationships and non-normal distributions [25]. These differences between Data Mining and the commonly used statistical approaches are assumed to supply more detailed and surprising results for the research field of BI and CPM. In particular, the research is working with Association Rule Discovery. Through Association Rule Discovery, the research aims to identify the strongest co-occurrence relationships between BI and CPM. It is believed that the results indicate the BI items most supporting to a successful and effective CPM. Furthermore, the outcomes will most likely provide more detailed insights in the relationship of BI and CPM.

V. RESEARCH METHOD AND RESULTS

A. Research Procedure

In the Data Mining literature, two main research procedures can be found, the Cross Industry Standard Process for Data Mining process model (CRISP-DM) or the overall procedure model Knowledge Discovery in Data bases (KDD) [5]. Both have the main process steps in common. The ones shown in Fig. 1 will be followed in this research. As the dataset is comparatively small, no selection of the appropriate dataset was seen as necessary. Therefore, the starting point for the data analysis was the pre-processing of the data. The data has been cleansed and missing, as well as conflicting values corrected. Cleve and Lämmel [5] suggest alternatives for dealing with missing values depending on the data structure. The important items of the questionnaire are formatted as Likert scale items and can be interpreted as metric data. Metric data can be pre-processed by replacing the missing values in the sample by the mean value of all item-based compiled answers. Alternatively, the mean values can be stated by contemplating the datasets closest to the dataset with the missing value. This idea follows the k-nearest neighbours (kNN) approach. Joenssen and Müllerleite [11] assess the kNN approach as practicable imputation method for missing Likert scale values if the dataset is small. Therefore, the missing values in the dataset were imputed using the kNN approach. After pre-processing, the data have been transformed in the required format for the applicable Data Mining technique. The applied Apriori Algorithm needs binary data [5]. Therefore, the Likert scale items have been transformed into binary variables. In the penultimate step, the data have been mined. Afterwards, in the discussion, the outcomes have been interpreted and evaluated. The interpretation and evaluation presupposes a subject knowledge background. As in every research, not all findings are valuable and of real-life meaning. Hence, only sensible research results should be discussed and applied. The decision about the sensibility of the research rests with the researcher and field experts.

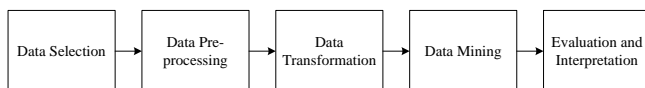


Figure 1. Research Procedure Model KDD

B. Data Collection

This research is based on the findings of [8], where a set of criteria that is seen as suitable to represent CPM on one hand, and BI on the other hand, has been identified. After an additional evaluation and definition of the pre-defined items, 20 CPM related items and 28 BI related items have been selected for further research (Table 1). A study has been conducted to bring the criteria of both fields together and to clarify the relationship between BI and CPM. Therefore, the identified criteria have been transformed into questionnaire items, which had to be answered on a five-point Likert scale. The anchor points at the ends of the scale have been “does not apply” and “fully applies” and an additional definition

“applies half and half” for the mid stage has been defined. The data collection has taken place from December 2014 until March 2015 using telephone interviews and an online questionnaire. Subjects were German companies who use BI for supporting their performance management. Hence, decision makers from management, controlling and IT were addressed. In total 169 questionnaires were completed resulting in a response rate of 11.3%. The participating companies are mainly mid-sized to large German firms belonging to the manufacturing industry.

VI. ANALYSIS AND RESULTS

Data Mining as a technique to discover new and unexpected patterns and relationships in data is the approach used to explore connections and associations between the BI and CPM criteria. In comparison to correlation or regression analysis, many Data Mining techniques do not imply connections in advance but discover them automatically. Association Rule Discovery is a popular pattern discovery method [20]. With association rules, co-occurrence relationships between data items can be discovered, taking into account as many research items as needed and available [5]. This indeed can lead on the upside to more detailed results and on the downside to an enormous amount of discovered association rules. Unmanageable amounts of association rules easily can be organized by instating measures to evaluate and select association rules based on their potential interestingness for the researcher [20]. These interestingness measures include *Lift*, *Support* and *Confidence* [5][16]. To generate association rules, many algorithms are available. The Apriori Algorithm is the classic procedure and works in two steps [21][30]. First, frequent itemsets exceeding the pre-defined *Support* threshold are identified. Therefore, the Apriori Algorithm initially finds itemsets containing of one item only. In the following steps, the algorithm includes one more item each round to the previously identified frequent itemsets until no more frequent itemsets are found [30]. Second, out of all frequent itemsets exceeding the pre-defined *Support* threshold confident association rules are generated. Hence, all identified frequent itemsets are separated into two subsets. The measure influencing which rules are understood as interesting is the *Confidence* measure [5].

In this research, Association Rule Discovery has been applied to find relation rules between BI and CPM. Before applying the Apriori Algorithm to the compiled dataset using the freeware Data Mining tool RapidMiner, the data had to be transformed into binary variables. This transformation can be done directly in RapidMiner. Questionnaire characteristics “does not apply” to “applies half and half” (1-3) have been transformed to *does not apply* and “does apply” and “fully applies” (4-5) to *does apply*. Furthermore, the minimum levels for the interestingness measures have been defined. Only association rules ($X \rightarrow Y$) with a minimum *Support* ≥ 0.6 have been considered as interesting, meaning that in at least 60% of the cases in the dataset the association rule has to show [16]. The confidence level has been set at *Confidence* ≥ 0.7 . This determines that in at least 70% of the rules where the first part of the rule (X) is shown, the second part of the rule (Y) has to show as well [16]. The measure *Lift* needs to be *Lift* > 1 to show

TABLE I OVERVIEW BI AND CPM ITEMS

BI items	CPM items
BI1_1: Clear roles and responsibilities for operating the BI systems	CPM1_1: Business management processes are transparent and traceable for managers
BI1_2: Data consistency (“Single Version of the Truth”)	CPM1_2: Business management process are documented throughout the company
BI1_3: 24/7 operation of the BI systems	CPM1_3: Business management processes are communicated throughout the company
BI1_4: Only compulsory BI tools are used	CPM2_1: Business management processes base on a common database
BI1_5: Data integrity during simultaneous use	CPM2_2: Management methods are fully automated and linked without manual support
BI1_6: Clear roles and responsibilities for the BI-development between the company’s departments and the IT throughout the whole enterprise	CPM2_3: Data in business management processes are complete
BI1_7: BI-architecture is documented	CPM2_4: Decision makers manual expenditure to edit reports is marginal
BI1_8: Master data changes are traceable	CPM3_1: Data in business management processes are relevant
BI1_9: BI relevant master data can be saved in various versions	CPM3_2: Data in business management processes are current
BI2_1: Use of feature set for predictive forecasting	CPM3_3: Effective use of external data (market data)
BI2_2: Use of feature set for describing data analysis	CPM4_1: Alignment of business management processes across all business functions
BI2_3: Use of feature set for information visualization	CPM4_2: Alignment of business management processes across all business units
BI3_1: Use of applications for scenario modelling	CPM4_3: Alignment of strategic and operational planning
BI3_2: Use of applications for statistical analysis	CPM5_1: Use of measurable indicators in all business functions
BI4_1: Each BI project is carried out using a standardized procedure model	CPM5_2: Use of measurable indicators in all business units
BI4_2: Each BI project bases on a standardized design method	CPM5_3: Use of measurable indicators in all operational business processes
BI4_3: Documentation standards for BI projects are clearly defined	CPM5_4: Use of measurable indicators in all strategic business processes
BI4_4: BI projects use agility	CPM6_1: Existence of feedback loops in operational business processes (e.g., complaint management)
BI5_1: Use of applications for adding describing comments	CPM6_2: Existence of feedback loops in strategy development (adjustment of vision, mission and the company’s strategy to environmental changes)
BI5_2: Use of applications for sharing comments throughout the enterprise	CPM6_3: Existence of feedback loops in strategic planning processes
BI5_3: Use of applications for automatic text processing and Text Mining	
BI6_1: Denotations and spellings are standardized in the BI databases	
BI6_2: BI tools for strategic business management are interoperable	
BI6_3: Manual expenditures for ensuring standardized spelling and denotations are marginal	
BI7_1: Applications for mobile usage of the BI Systems are available	
BI7_2: Applications for the mobile usage of the BI Systems are used	
BI8_1: Use of BI applications for implementing alerts linked to automated workflow data in operational business processes	
BI8_2: Use of BI applications for implementing alerts linked to automated workflow data in strategic business processes	

a positive dependency between the items of a rule for the occurrence of the items [5]. Regarding the minimum settings of the measures, 103 association rules have been discovered.

Association rules do not imply causality. They find items that imply the presence of other items [20]. As the research focus is on the benefits of BI for CPM, the attention lies on association rules beginning with BI items, leaving 52 association rules to evaluate. The association rules with the highest *Support* are shown in Table 2.

It is conspicuous that especially the CPM items *Data in business management processes are relevant* and *Data in business management processes are current* apply in a company, if specific BI items apply either. In more detail, these two CPM items most likely apply in a company, if in addition to the items in Table 2 the following BI items apply as well:

- *Data consistency (“Single Version of the Truth”),*
- *Only compulsory BI tools are used,*

- *Master data changes are traceable,*
- *Clear roles and responsibilities for the BI-development between the company’s departments and the IT throughout the whole enterprise.*

Also, the BI item *Use of applications for automatic text processing and Text Mining* is found in combination rules with the item *Clear roles and responsibilities for operating with the BI system* and *Data integrity during simultaneous use*. Different from these two, *Use of applications for automatic text processing and Text Mining* has the characteristic does not apply. Still, the CPM items *Data in business management processes are relevant* and *Data in business management processes are current* apply, indicating that data currency and relevance is rather given if Text Mining and context processing tools are not used in a company.

Furthermore, the association rules illustrate that:

TABLE II. STRONGEST ASSOCIATION RULES, STARTING WITH BI ITEMS

BI items	→	CPM items	Interestingness
Data integrity during simultaneous use=applies	→	Data in business management processes are relevant=applies	Support=0.83 Confidence=0.92
Clear roles and responsibilities for operating the BI systems=applies	→	Data in business management processes are relevant=applies	Support=0.80 Confidence=0.93
Data integrity during simultaneous use=applies	→	Data in business management processes are current=applies	Support=0.78 Confidence=0.86
Data integrity during simultaneous use=applies and Clear roles and responsibilities for operating the BI systems=applies	→	Data in business management processes are relevant=applies	Support=0.76 Confidence=0.93
Data integrity during simultaneous use=applies	→	Data in business management processes are relevant=applies and Data in business management processes are current =applies	Support=0.74 Confidence=0.83
Clear roles and responsibilities for operating the BI systems=applies	→	Data in business management processes are current=applies	Support=0.74 Confidence=0.86
Clear roles and responsibilities for operating the BI systems=applies	→	Data in business management processes are relevant=applies and Data in business management processes are current =applies	Support=0.73 Confidence=0.84
24/7 operation of the BI systems=applies	→	Data in business management processes are relevant=applies	Support=0.70 Confidence=0.91

- Use of BI applications for implementing alerts linked to automated workflow data in strategic business processes does not apply,
- Use of applications for sharing comments throughout the enterprise does not apply,
- Use of applications for adding describing comments does not apply,
- Use of applications for automatic text processing and Text Mining does not apply

the CPM item *Management methods are fully automated and linked without manual support* does not apply as well.

VII. DISCUSSION

CPM is a management strategy for decision support [19]. This support is achieved by using measures and KPI's (Key Performance Indicator) from data. The information gained is used by decision makers and managers to monitor the companies target achievements. If necessary, strategy, processes and goals are adjusted to ensure the company's survival and success. Data is the quintessence in CPM but only useful if provided when needed and of high quality. The association rules show that if BI items related to the subject of data quality and data provision (e.g., *Data consistency, Data integrity during simultaneous use*) are high and apply in a company the *Data in the business management processes are relevant and current*. The rules illustrate the connection between data and business management processes and therefore the connection between BI and CPM. Supported with high quality data, decision makers can act and rely on actionable information to manage the enterprise. The rules underline the function of BI as a decision support tool needed for a successful CPM. The concentration on business management processes as the CPM part of the rule highlights the understanding of CPM as a multiplicity of business management processes connected and integrated into each

other [12]. If the processes in a company are managed, based on needed high quality data, it is the initial point for an overall effective CPM. Nevertheless, a CPM strategy is not implemented in one run. The implementation is a slow process carried out in sub-steps [19]. The focus of the association rules on *Data in business management processes is relevant and current* supports this theory. It is indicated that first the attention has to lie on the management processes separately. Once a company is working on high quality data when needed, a good connection throughout the enterprise is given as well. The lack of association rules containing further CPM items might be an indicator that most companies are assumedly still working on implementing a thorough performance management.

The second set of association rules discovered that if no opportunity to use and share comments within an enterprise is given as well as the opportunity to use unstructured data a full automation and linkage of the company's management methods without manual support is not given as well. Management methods are ideally accepted process descriptions for dealing with certain issues (e.g., *Balanced Scorecard*) [19]. These methods can only be successful if goal oriented, understood and used continuously [19]. Consequently, management methods are focused on the definition and analysis of measures. For all measures to be useful, a reference magnitude is needed, which can be supplied by adding and sharing comments. Furthermore, the association rules imply that fully automated management and planning methods are dependent on the use of comments for ensuring transparency as well. Only if supported by describing comments, automated management processes and planning methods are understandable throughout a company and manual support is minimized.

Text Mining enables knowledge discovery from semi-structured or unstructured data. This is a rather advanced

analysis method of BI and the rules indicate that if there is no or not much *usage of automatic text processing and Text Mining*, *Data in business management processes* are still *relevant* and *current* but the *Management methods* are not fully *automated or linked without manual support*. Text Mining is an advanced research method used to gain new information from texts. The association rules suggest, that this feature of BI is rather not important for the data currency and relevance in the business management processes. Therefore, it might be ignored in the establishment process of CPM. But it seems to be interesting once the automation of management methods without manual support wants to be achieved.

The association rules discovered only comprise 3 different CPM related items *Data in business management processes are current*, *Data in business management processes are relevant* and *Management methods are fully automated and linked without manual support*. This awakes the awareness that BI is not the only technological support in companies. Enterprise Resource Planning Systems (ERP), Customer Relationship Systems (CRM) and Supply-Chain-Management System (SCM) also play an important role for a successful performance management. Before focusing on implementing a BI solution, the predominant step might be to focus on existing software first and afterwards built an effective BI solution on top.

VIII. CONCLUSION

In comparison to the subject related research, the results of the Data Mining approach show more detailed information about the connection of BI and CPM. Instead considering BI and/or CPM as a whole, with Data Mining all BI and CPM features have been taken into account, allowing researchers and practitioners comprehensive insights into the relationship between these two interdependent disciplines. Besides simply proving a positive relationship, the research outcomes allow conclusions on a path of action for improving a company's CPM through the correct usage and implementation of BI. Although these inferences still need further investigation in practice, it has been possible to identify the BI and CPM items with the strongest connection through association analysis. Inferentially, the Data Mining approach presents itself as a suitable research procedure in IS research.

But this research still is only a first step in exploring the possibilities Data Mining holds for IS research. Future studies need to evaluate if and how Data Mining can be used to gain detailed research insights.

REFERENCES

- [1] M. Aho, "The Distinction between Business Intelligence and Corporate Performance Management - A Literature Study Combined with Empirical Findings", Proceedings of the MCSP 2010 Conference, 2010.
- [2] K. Backhaus, B. Erichson, W. Plinke, and R. Weiber, *Multivariate analysis: An application-oriented introduction*, 13th edn., Springer, Berlin, 2011.
- [3] J. Becker, D. Maßing, and C. Janiesch, "An evolutionary process model for introducing Corporate Performance Management Systems", *Data Warehousing*, pp. 247–262, 2006.
- [4] www.researchandmarkets.com/reports/1055897, retrieved: 2, 2015.
- [5] J. Cleve and U. Lämmel, *Data Mining*, De Gruyter Oldenbourg, München, 2016, p. 187, 216 ff., 235.
- [6] M. L. Gargano and B. G. Raggad, "Data Mining - a powerful information creating tool", *OCLC Systems & Services: International digital library perspectives*, 15(2), pp. 81–90, 1999.
- [7] M. Hannula and V. Pirttimäki, "Business intelligence empirical study on the top 50 Finnish companies", *Journal of American Academy of Business*, 2(2), pp. 593–599, 2003.
- [8] K. Hartl, O. Jacob, F. H. Lien Mbep, A. Budree, and L. Fourie, "The Impact of Business Intelligence on Corporate Performance Management", *Proceedings of the 49th HICSS Conference*, pp. 5041–5051, 2016.
- [9] J. Jackson, "Data Mining; A Conceptual Overview", *Communications of the Association for Information Systems*, 8(1), pp. 267–296, 2002.
- [10] O. Jacob and F. H. Lien Mbep, "Factors to Determine the Value of Business Intelligence to Corporate Performance Management", *University of Applied Sciences Neu-Ulm*, 2014.
- [11] D. W. Joenssen and T. Müllerleite, "Missing Data in Data Mining", *HMD Praxis der Wirtschaftsinformatik*, 51(4), pp. 458–468, 2014.
- [12] M. Lang, ed., *Handbook of Business Intelligence: Potentials, Strategies, Best Practices*, 1st edn., Symposium, Düsseldorf, 2015.
- [13] F. H. Lien Mbep, O. Jacob, and L. Fourie, "Critical Success Factors of Corporate Performance Management (CPM) Literature Study and Empirical Findings", *BUSTECH Conference Proceedings*, pp. 6–14, 2015.
- [14] http://legacy.wlu.ca/documents/22449/07_Measuring_the_Benefits_of_BI_Viva.pdf, retrieved: 02, 2016.
- [15] S. Miranda, "Beyond BI: Benefiting from CPM Solutions", *Financial Executive*, 20(2), pp. 58–61, 2004.
- [16] R. M. Müller and H.-J. Lenz, *Business Intelligence*, Springer Berlin Heidelberg, Berlin, Heidelberg, 2013.
- [17] S. Natek and M. Zwillling, "Data Mining for small student datasets - knowledge management system for higher education teachers", *Management, Knowledge and Learning Conference*, pp. 1379–1398, 2013.
- [18] S. Negash, "Business Intelligence", *The Communications of the Association for Information Systems*, 13(1), pp. 177–195, 2004.
- [19] K. Oehler, *Corporate Performance Management with Business Intelligence tools*, Hanser, München, 2006.
- [20] K.-M. Osei-Bryson and O. Ngwenyama, "Advances in Research Methods for Information Systems Research: Data Mining, Data Envelopment Analysis, Value Focused Thinking", Springer, New York, 34, 2014.
- [21] H. Petersohn, *Data Mining: Methods, Processes and Application Architecture*, Oldenbourg, München, 2005.
- [22] G. Richards, W. Yeoh, A. Y.-L. Chong, and A. Popovic, "An empirical study of business intelligence impact on corporate

- performance management", Proceedings of the Pacific Asia Conference on Information Systems 2014, pp. 1–16, 2014.
- [23] S. Rouhani, A. Ashrafi, A. Zare Ravasan, and S. Afshari, "The impact model of business intelligence on decision support and organizational benefits", *Journal of Enterprise Information Management*, 29(1), pp. 19–50, 2016.
- [24] R. A. Saed, "The Relationship between Business Intelligence and Business Success: An Investigation in Firms in Sharjah Emirate", *American Journal of Business and Management*, 2(4), pp. 332–339, 2013.
- [25] A. J. Stolzer and C. Halford, "Data mining methods applied to flight operations quality assurance data: a comparison to standard statistical methods", *Journal of Air Transportation*, 12(1), pp. 6–24, 2007.
- [26] N. Urbach and F. Ahlemann, "Structural equation modeling in information systems research using partial least squares", *JITTA: Journal of Information Technology Theory and Application*, 11(2), pp. 5–40, 2010.
- [27] V. E. Vinzi, C. Wynne, J. Henseler, and H. Wang, *Handbook of partial least squares: Concepts methods and applications*, Springer, Berlin, 2010.
- [28] S. Williams and N. Williams, "The Business Value of Business Intelligence", *Business Intelligence Journal*, 8, pp. 30–39, 2003.
- [29] N. Yogeve, L. Fink, and A. Even, "How Business Intelligence Creates Value", Proceedings of the ECIS Conference, 2012.
- [30] R. Agrawal and R. Srikant, "Fast Algorithms for Mining Association Rules", Proceedings of the 20th VLDB Conference Santiago, Chile, pp. 487–499, 1994.