Calculating Key Performance Indicators of State Commercial Banks using Linked Open Data

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Abstract. Our goal is to calculate key performance indicators based on Linked Data sources that use the RDF Data Cube vocabulary to represent numeric data. We use SPARQL queries to select company figures and calculate ratios. The SPARQL queries operate over data collected from multiple sources. We use a rule engine to execute programs that specify data collection. We point out strengths and weaknesses of the approach, and argue that the approach generalises beyond the initial use case of U.S. banks. We provide survey results of 15 information engineering and management students assessing the applicability of our approach. Finally, we conduct initial performance tests to show the feasibility of data collection via Linked Data requests during query evaluation.

1 Introduction

Financial data is relevant in several contexts. Companies try to detect weak points in everyday processes or improve the companies efficiency with regards to handling financial aspects. Investors analyse financial data of companies to spot investment opportunities. Governments mandate that companies publish quarterly and annual reports to ensure transparency. Regulators need to assess the health of companies (especially in the financial sector) to ensure a stable economy. All these are in need of a huge amount of information from different sources to handle their tasks.

A typical part of financial analysis is the computation of Key Performance Indicators (KPIs). Thus, we study approaches to calculate KPIs on data that originates from two or more origins. Our use case underlines the relevance of data from various information systems for everyday work of analysts. Additionally the results of the evaluation support the thesis by O'Riain et al. [O'CH12], who stated that a further awareness of general facts regarding the company can lead to a competitive advantage.

Our use case is set against the background of analysing KPIs of U.S. state commercial banks. The U.S. Securities and Exchange Commission (SEC) lists a huge amount of companies in the commercial state bank sector, offering a reasonable quantity of information that can be contemplated within the use case. We also make use of data from Yahoo! Finance[1]. Data from SEC and Yahoo!

[1] http://finance.yahoo.com/

Finance is available as Linked Data, using the Data Cube vocabulary[2]. We also use DBpedia[3], which however does not support the Data Cube vocabulary yet (and thus does not provide information from different timestamps). With the increasing availability of open data that already adheres to a common representation (Linked Data expressed in the Data Cube vocabulary), queries over multiple sources become cheaper and easier to carry out.

We address the following research questions:

1. How much effort is required to collect and integrate data from multiple sources so that SPARQL queries can be used to calculate KPIs? We test the general practicability as well as advantages and disadvantages of our approach.
2. Does our approach ease the everyday work of financial analysts by driving value for their customers? We asses the value for both customers and analysts by a survey of future information and management engineering professionals. That is, we test whether the ascertained outputs really are relevant and helpful.
3. Are data collection and SPARQL query evaluation executable with good performance? We point out differences in performance by comparing an approach that carries out data gathering and query evaluation separately with an approach where both data gathering and query evaluation are intertwined.

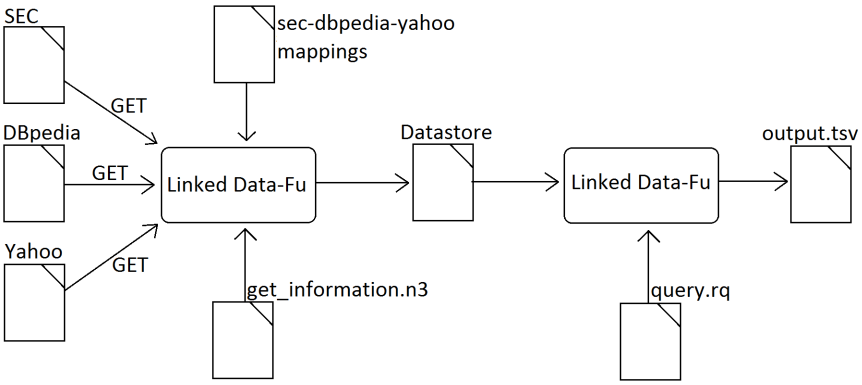

Fig. 1. Data integration from various sources – adopted from [KWOW+14]

We can now summarise the main components of our approach depicted in figure 1. By collecting and querying the (numerical) data we found available in the Data Cube format we analyse selected KPIs. Maximising the benefits and advantages our approach could lead to was probably the biggest challenge we faced.

[2] `http://w3.org/TR/vocab-data-cube/`
[3] `http://dbpedia.org/`

Therefore we needed to ensure an appropriate knowledge of both economics and informatics. By this point we focussed on queries handling with important numbers to customer and analysts. Our work provides highly configurable queries that can be adopted to other scenarios and branches. Furthermore we offer reproducible outputs by providing queries and practices as well as instructions via GitHub[4].

Thereby generated data can be used for statistical analyses in finance contexts. We also present possibilities offered when using the Linked Data-Fu tool to interested parties [SSHS13]. When executed correctly our approach can simplify (statistical) competitors analysis including arbitrary choice of KPIs an analyst may want to compare, provided the needed data is available.

The remainder of the paper is structured as follows: Section 2 provides conceptual background and related work. Section 3 presents the use case, including the definition of KPIs. Section 4 covers methodology, and section 5 presents the evaluation and findings. Section 6 concludes.

2 Conceptual background and related work

The presented process of hypothesis development requires some previous information to be understood properly. Especially knowledge in the current research state regarding translations from eXtensible Business Reporting Language (XBRL), which is used to present financial statements via eXtensible Markup Language (XML) syntax, to Resource Description Framework (RDF), basics of the Data Envelopment Analysis (DEA) and the Linked Data-Fu, which was used to test both general usability and performance of the queries, is needed.

First of all we require access to data in XBRL format as RDF, to ensure further possibilities and more flexibility in regards of data analysis [Mill98] from different sources. Our approach evaluates three different procedures before coming to the conclusion that the one from Kämpgen et al. [KWOW+14] fits the given context and the hypothesis that is to be proven best. The reasons behind dropping the two other approaches out of consideration were that XBRL instance documents and their corresponding taxonomies were translated separated from each other and into different languages ([GaGi10], [BRLD10]).

Furthermore, basic knowledge of the economical topic of Data Envelopment Analysis (DEA) is needed. Our lightweight version of DEA makes use of the simple rule that every output a company generates can be divided through any input that influences the company and its products or service, as long as both are quantifiable and non-negative values ([Geye14], [Wei01]). We use these facts to compute relevant business ratios in the use cases context [ChCP08] with inputs and outputs integrated from different data sources.

At this point all preparations needed to fill up our RDF store with data from different sources are made. To enable data analysis and performance tests, we needed software to run SPARQL–queries above these store, as shown in figure 1.

[4] `https://github.com/abuescher/financial-linked-open-data-integration/`

Thus we used the Linked Data-Fu [SSHS13], which allows for data collection, integration and query evaluation. Given a datastore the programs output is the specific amount of triples that meet all requirements of the given query. Section 5.3 presents the results of these tests.

3 Use case

The following chapter presents the selected use case for our approach. We selected the financial sector due to the importance in the recent financial crisis. Please note that there were some sector restricted measures that can be adapted to other sectors. Further measures can be applied to all different kinds of sectors.

3.1 Preparations

While all knowledge and content related requirements have been met now, there is a small technical addition needs to be provided as well, before presenting the case. The arguably most important aspect of this approach includes the possibility of data integration from various sources. The initial datastore only consists of triples linking two sources[5]

Code 1.1. Linking resources using the owl:sameAs property

```
edgarcik:{CIK#id} owl:sameAs dbpedia:corresponding_bank .
```

This example shows the general idea how we linked different sources. Please note that the CIK number ({CIK#id} in this illustration) needs to be replaced with the actual CIK number of the considered bank.

Also bear in mind that this example shows the connection between the SEC and DBpedia data. More data sources can be easily integrated by replacing the DBpedia URI with the source to be integrated (e.g. Yahoo!Finance). Therefore the needed triple has to be added for every bank and every source exactly once.

Having these links set up, we enhanced our queries by an additional part[6]:

Code 1.2. Using httpm:GET to access data from different sources

```
{
  ?companySEC edgar:cikNumber ?number .
  ?companySEC owl:sameAs ?companyNewSource .
} => {
[] http:mthd httpm:GET ;
   http:requestURI ?companyNewSource . } .
```

We appropriate the HTTP GET method to ensure that we can use information from the integrated data source. In the given example we would be able to include data from all origins that were linked with the triple presented in Code 1.1. The next chapter shows the usability in different scenarios.

[5] Please find paths to the used prefixes on `http://prefix.cc/`.

3.2 Key Performance Indicators (KPIs) selection

The selection of key figures is a difficult, complex and non–structured task. In our context of bank performance multiple different approaches have been made [KPDZ06] – a significant proportion came to the conclusion that only taking standardised figures into consideration, will not necessarily lead to reliable statements regarding performance (e.g. [HJSC97] and [BhSh07]).
After taking a large amount of different data into consideration, we downsized them to a total number of five KPIs to be evaluated in our use case. The first three KPIs adhere to the DEA method, relating output and input measures of a company.

Total turnover per employee: First, we took the total turnover per employee [SeZh99] into our interpretations:

$$\frac{totalTurnover}{numberOfEmployees} \tag{1}$$

This is the first time we make use of our link between the representing URIs of the SEC data as well as the corresponding DBpedia index.

Production efficiency: A very interesting point in the context of state commercial banks is their evaluation in terms of production effectiveness, as banks do not have a production in the classical sense. Giokas [Giok08] split the efficiency as a whole into three separated and independent parts: "Production Efficiency", "Transaction Efficiency" and "Intermediation Efficiency". We decided to choose the Production efficiency to be evaluated more detailed.
Wu concluded that the production effectiveness of banks can be evaluated by dividing the Non–interest income through the accumulated personnel costs (Table 1,[Wu12]):

$$\frac{Non-interestIncome}{PersonnelCosts} \tag{2}$$

Both needed information can be extracted from the appropriative SEC documents.

Total turnover per location: Another important aspect in context of choosing a bank institution is the geographical penetration [DeGe05]. We determine this KPI by dividing the total turnover through the number of offices a company has:

$$\frac{totalTurnover}{numberOfLocations} \tag{3}$$

To compute this KPI, we repeatedly made use of the DEA's characteristics and also integrated data from two different sources, namely the SEC and DBpedia.

Gains and losses for multiple periods: One of the most basic KPIs are gains and losses companies observed. Long–term losses and gains are one of the most significant parameters when it comes to judging reliability and stability of banks [AlGa09]:

$$\sum_{t=0}^{n} NetIncomeLoss(t) \tag{4}$$

There is another reason for taking losses and gains into our consideration. We suspect these to demonstrate the most significant impact on the chart–development in regards of the price of a companies shares, which will be tested within the next and final part of the use case that shows a preview on the possibility to test different impacts on the price of shares.

Prospect – Price of shares: Considering the integration from share–related data, we could analyse the effect of different key figures on their price development. By comparing the trends of both the considered characteristic number as well as the price of shares, we could give answers on two important questions:

1. Does the considered characteristic impact the price of shares at all?
2. If present, how large is the impact?

Table 1 sums up all chosen KPIs as well as their corresponding URIs presenting the needed data from different sources.

Below we present some exemplary outputs from the given KPIs. We used an exemplary company to make our approach more concrete. Please note that the presented examples can be adapted to any other listed SEC filing easily – this also applies to data from Yahoo or DBpedia. For our illustrations we used the given information of the Fifth Third Bancorp[6] from various sources[7] [8] [9] as well as available information of Wilmington Trust Corp[10].

3.3 Results

For our result section we divided our tests into two parts:

1. individual performance tests regarding the previously listed KPIs
2. a competitors analysis, showing results from different companies on particular key figures

Table 2 illustrates the Fifth Third Bancorp's development over one year in terms of production efficiency while table 3 gives an example of an output of the competitors analysis considering the total turnover per employee as chosen KPI. The upcoming chapter presents our evaluation's methodology.

[6] `https://www.53.com/site`
[7] `http://www.sec.gov/cgi-bin/browse-edgar?action=getcompany&CIK=35527`
[8] `http://dbpedia.org/resource/Fifth_Third_Bank`
[9] `http://finance.yahoo.com/q?s=FITB`
[10] `https://www.wilmingtontrust.com/`

No.	KPI	Data origin(s)	Corresponding URIs
1	$\frac{totalTurnover}{numberOfLocations}$	SEC DBpedia	us-gaap2009:totalTurnover dbpedia-owl:numberOfEmployees
2	$\frac{Non-interestIncome}{PersonnelCosts}$	SEC SEC	us-gaap2009:noninterestIncome us-gaap2009:LaborAndRelatedExpense
3	$\frac{totalTurnover}{numberOfLocations}$	SEC DBpedia	us-gaap2009:totalTurnover dbpedia-owl:numberOfLocations
4	$\sum_{t=0}^{n} NetIncomeLoss(t)$	SEC	us-gaap2009:NetIncomeLoss
5	Price of shares	SEC Yahoo	– yahoo:Close

Table 1. Overview of the considered KPIs in the presented case

4 Methodology

The simplification of financial analysts everyday work and driving value to the customer is one of the three parts of our main hypothesis. In order to test this aspect we decided to conduct a survey and present our findings to an appropriate audience.

4.1 Design and sample

To be able to recognise the whole possibilities our approach presents, we needed participants who exhibit a basic knowledge in both informatics (Semantic Web in the best case) and economics. Therefore we had chosen our sample to be all students of Information Engineering and Management who exactly offer the needed expertise for our case [GSTa03].
The questionnaire was inspired by the work of Weijters et al. from 2010 [WeCS10] and Weathers et al. from 2005 [WeSN05]. Both drew the conclusion that five point likert scales (fully labeled) lead to the best results in terms of validity

?result	?nonInterestIncome	?personnelCosts
1.262	3267000000	2874000000
1.338	3967000000	2965000000

Table 2. Fifth Third Bancorp production efficiency 2009 and 2010

and response bias. The questionnaire consisted of two parts. In the first part all participants were asked to estimate their knowledge in terms of informatics and economics in general and in terms of Semantic Web and Finance and Accounting specifically. The second part of the survey consists of nine statements. All participants were asked to rank their degree of acceptance respectively refusal on a five-point Likert scale.

?result	?cikNr	?name
431915	35527	FIFTH THIRD BANCORP
332087	22356	COMMERCE BANKSHARES INC
322478	36270	M&T BANK CORP

Table 3. Competitors analysis – turnover per employees (excerpt)

We randomly chose a total number of 15 students as participants for our survey, representing 2.85%[11] of all Information Engineering and Management students of the Karlsruhe Institute of Technology (KIT). In groups of three people a short and objective lecture was hold that pointed out the basic ideas of the approach. Afterwards the survey was handed out to attendees.

4.2 Quality measurements

When designing the questionnaire we took quality management into our considerations. Inspired by the work of Weathers et al. [SwWN08] we decided to include three reversed–item pairs into the survey to ensure an appropriate grade of validity and consistency.

In the next step we defined a misresponse to a reversed–item pair. By doing so we determined that in our case a misresponse is rating the first half of the pair with "strongly agree" or "slightly agree" while **not** rating the second part of the pair with either "strongly disagree" or "slightly disagree" and vice versa. Rating one part of the reversed–item pair with "neutral" leaves the pair without misresponse. These calculations leave us with three potential misresponses per participant and thus a maximum of 45 in total. Only **one** of these possible 45 mistakes has been done resulting in the satisfying number of only about 2.22% misresponse to reversed–items.
Additionally we decided to evaluate our internal consistency by computing the standardised Cronbach's alpha [TaDe11]. We took advantage of the specific rule for Likert scales: $\alpha_{st} \leq \alpha_u$ with α_{st} being the standardised Cronbach's alpha and α_u being the usual one. After computing $\alpha_{st} = 0.7441$ we could already state our internal consistency as acceptable [Geor03].

5 Evaluation and findings

In terms of structuring the evaluation we stuck to our three-folded hypothesis. In the first part a detailed analysis, discussing advantages as well as disadvantages from our point of view is given. The second subtopic consists of a reporting on given opinions from our survey's participants and the conclusions we drew. The chapter closes with hard facts as results of our performance tests.

[11] status as of October, 2014

5.1 Discussion

We faced the task of an appropriate choice of KPIs. In this context we do not only speak of the right amount of different examples but also of figures we can access the needed information for. As trivial this may sound, the challenge turned out tremendous. However, we were able to determine significant and exemplarily adequate figures so we could point out a total amount of five examples that illustrate possibilities and restrictions quite well.

In terms of complexity we met mixed experiences. The DEA itself was easily adapted and fitted the context of data integration from various sources acceptably well. Especially in terms of the competitors analysis we had to deal with bigger and more complicated SPARQL–queries. Therefore we evaluated queries above a way larger datastore than for other queries, which obviously leaded to inferior performance results, as will be presented in the next chapter.

A promising prospect is given by the use of the fifth key figure (integration from Yahoo stock data linked to data from the SEC). The approach knows how to demonstrate his advantages and opportunities especially when it comes to dynamic interactions between different numbers. Analysts can easily determine if there is an impact from one KPI on another.
One negative aspect is the connection between two data origins that has to be inserted by hand once (cf. code 1.1), which takes about 30 seconds up to one minute for every inserted bank. A possible workaround is an automatically handling of newly inserted companies into the initial datastore. Once a company is added to the datastore for the first time the link between the SEC dump and the corresponding sources is generated automatically by making use of their connected name linked via the `foaf:name` property. Obviously there can be differences between this attribute and the URI representing the corresponding company that have to be dealt with.

In sum, we can record the general confirmation of the first subtopic of the main hypothesis. First of all there are bounds to our approach without any doubt. The most problematic aspect is probably the difference in publications in XBRL, meaning the possibilities for companies to introduce their own financial facts by defining them in their own taxonomy documents. Replacing the usually used financial facts with these specially developed ones significantly impairs to ensure the general usability. Besides that there is no question that the demanded accomplishments could be presented by our use case and thus generally support the first part of our main hypothesis.

5.2 Survey results

Our survey aimed on two different aspects. On the one hand we wanted to evaluate how much prior knowledge in topics of both Semantic Web and finance and accounting are needed to feel comfortable with our approach. On the other hand it was our intention to point out the significance of our illustrations for companies. According to our needs we designed 13 questions.

The evaluation fits our hypothesis well. We asked the participants to give us their impressions on the usability and relevance from a companies point of view. Additionally we requested them to estimate whether companies would use our approach or not. About 73% stated that they support the statement, saying companies would use the concept. Also about 93% respectively 98% supported our perception on usability and relevance.

The results from our evaluation on needed prior knowledge turn out similarly positive. While about 40% of the participants estimated their prior knowledge in informatics above average, only 26% did so in the Semantic Web context. Still approx. 75% supported our presentation of an easy to adapt approach. Even though survey attendees ranked their knowledge in terms of general topics in business economics (approx. 80% above average) and in finance and accounting in particular (approx. 53% above average) quite high, we still sicern our thesis supported in terms of a low degree of complexity

We secured data validity and quality by two concepts (reversed-item pairs and Cronbach's alpha) which both approve our methodology in these terms. Independent quality tests underline both consistency and validity of the survey's design and thus our results supporting the second part of the main hypothesis.

5.3 Performance

For our performance tests we ran the different queries on our server: 2x Intel(R) Xeon(R) CPU E5-2670 0 @ 2.60GHz CPU, consisting of 128 GB memory (RAM) and running on 16 cores (32 with Hyperthreading). To ensure that our tests delivered both comparable and qualitative results we started all tests when the CPU load showed (nearly) 0%.

No.	Data origin(s)	Incl. http:GET	Excl. http:GET	# of triples
1	SEC + DBpedia	15m32s	3.16s	55k
2	SEC	13m58s	2.79s	51k
3	SEC + DBpedia	15m42s	3.55s	55k
4	SEC	13m48s	2.88s	51k
5	SEC + Yahoo	17m02s	11.30s	1.203k
All	SEC + DBpedia + Yahoo	18m14s	25.24s	1.211k

Table 4. Performance test results

All tests were performed with version 0.9.3 of the Linked Data-Fu engine [SSHS13].

While the first five queries accord to the listing in table 4 the sixth call evaluated all five previous queries and their corresponding output in one single call[12]. We divided our tests into two different procedures. The first approach

[12] Please find more examples for querying Linked Open financial data on GitHub: `https://github.com/abuescher/financial-linked-open-data-integration`

integrated data and evaluated queries live, which means evaluated data was included in real-time by using http:get on considered sources. The second one evaluated queries over an already built dataset, which can be updated on a regular basis.

One aspect that extends the needed execution time slightly is including data from DBpedia and especially Yahoo compared to only using information from the SEC documents. The times indicate the commensurability of the trade-off between complexity and performance. Concluding we can say that the practicability with good performance can still be seen as supported.

6 Conclusion

We have assessed the effort required to collect and integrate financial data about U.S. state commercial banks using a Linked Data abstraction. Our general approach is applicable to other companies, KPIs and sources. To include more companies, one would need to construct the `owl:sameAs` relationship between URIs representing the same company from the three sources. To include more KPIs, one would need to write the SPARQL queries that select the correct numbers. To include more sources, one would need to gain access to relevant statistical data available as Linked Data, ideally already expressed in the Data Cube vocabulary. Possible future work could include the addition of more companies, KPIs and data sources, and the study of data visualisation methods on the resulting KPIs.

References

[AlGa09] Ugo Albertazzi and Leonardo Gambacorta. Bank profitability and the business cycle. *Journal of Financial Stability*, 5(4), 2009, S. 393–409.

[BhSh07] Rajat Bhagwat and Milind Kumar Sharma. Performance measurement of supply chain management: A balanced scorecard approach. *Computers & Industrial Engineering*, 53(1), 2007, S. 43–62.

[BRLD10] Jie Bao, Graham Rong, Xian Li and Li Ding. Representing Financial Reports on the Semantic Web: a Faithful Translation from XBRL to OWL. In *Proceedings of the 2010 International Conference on Semantic web rules*, 2010.

[ChCP08] Tser-yieth Chen, Chie-Bein Chen and Sin-Ying Peng. Firm operation performance analysis using data envelopment analysis and balanced scorecard: A case study of a credit cooperative bank. *International Journal of Productivity and Performance Management*, 57(7), 2008, S. 523–539.

[DeGe05] James Devlin and Philip Gerrard. A study of customer choice criteria for multiple bank users. *Journal of Retailing and Consumer services*, 12(4), 2005, S. 297–306.

[GaGi10] Roberto Garcia and Rosa Gil. Triplificating and linking XBRL financial data. In *Proceedings of the 6th International Conference on Semantic Systems*, 2010.

[Geor03] Darren George. *SPSS for windows step by step: A simple study guide and reference, 17.0 update, 10/e.* Pearson Education India. 2003.

[Geye14] Andreas Geyer-Schulz. IISM/EM Information Services & Electronic Markets Karlsruhe Institute of Technology (KIT) – BWL der Informationsunternehmen, Vorlesung 6. Entscheidungen bei Sicherheit (Teil 2), 2014.

[Giok08] Dimitris I Giokas. Assessing the efficiency in operations of a large Greek bank branch network adopting different economic behaviors. *Economic Modelling*, 25(3), 2008, S. 559–574.

[GSTa03] Andreas Geyer-Schulz and Alfred Taudes (Hrsg.). *Informationswirtschaft ein Sektor mit Zukunft.* Band 0 der *Lecture Notes in Informatics (LNI)*, Köllen Druck+Verlag GmbH, Bonn, 2003.

[HJSC97] Claude A Hanley Jr, Mark P Suter and Steve Cocheo. Banking's Top Performers. *ABA Banking Journal*, 89(7), 1997, S. 36.

[KPDZ06] Kyriaki Kosmidou, Fotios Pasiouras, Michael Doumpos and C Zopounidis. Assessing performance factors in the UK banking sector: a multicriteria methodology. *Central European Journal of Operations Research*, 14(1), 2006, S. 25–44.

[KWOW+14] Benedikt Kämpgen, Tobias Weller, Seán O'Riain, Craig Weber and Andreas Harth. Accepting the XBRL Challenge with Linked Data for Financial Data Integration. In *International Semantic Web Conference*, S. 595–610. Springer, 2014.

[Mill98] Eric Miller. An introduction to the resource description framework. *Bulletin of the American Society for Information Science and Technology*, 25(1), 1998, S. 15–19.

[O'CH12] Seán O'Riain, Edward Curry and Andreas Harth. XBRL and open data for global financial ecosystems: A linked data approach. *International Journal of Accounting Information Systems*, 13(2), 2012, S. 141–162.

[SeZh99] Lawrence M Seiford and Joe Zhu. Profitability and marketability of the top 55 US commercial banks. *management science*, 45(9), 1999, S. 1270–1288.

[SSHS13] Steffen Stadtmüller, Sebastian Speiser, Andreas Harth and Rudi Studer. Data-Fu: A Language and an Interpreter for Interaction with Read/Write Linked Data. In *Proceedings of the 22nd International Conference on World Wide Web*, WWW '13, 2013, S. 1225–1236.

[SwWN08] Scott D Swain, Danny Weathers and Ronald W Niedrich. Assessing three sources of misresponse to reversed Likert items. *Journal of Marketing Research*, 45(1), 2008, S. 116–131.

[TaDe11] Mohsen Tavakol and Reg Dennick. Making sense of Cronbach's alpha. *International journal of medical education*, Band 2, 2011, S. 53.

[WeCS10] Bert Weijters, Elke Cabooter and Niels Schillewaert. The effect of rating scale format on response styles: The number of response categories and response category labels. *International Journal of Research in Marketing*, 27(3), 2010, S. 236–247.

[Wei01] Quanling Wei. Data envelopment analysis. *Chinese Science Bulletin*, 46(16), 2001, S. 1321–1332.

[WeSN05] Danny Weathers, Subhash Sharma and Ronald W Niedrich. The impact of the number of scale points, dispositional factors, and the status quo decision heuristic on scale reliability and response accuracy. *Journal of Business Research*, 58(11), 2005, S. 1516–1524.

[Wu12] Hung-Yi Wu. Constructing a strategy map for banking institutions with key performance indicators of the balanced scorecard. *Evaluation and Program Planning*, 35(3), 2012, S. 303–320.